HEALTH AND SAFETY ASPECTS
OF THE USE OF
MECHANICALLY DEBONED POULTRY

Food Safety and Quality Service
U.S. Department of Agriculture
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Background of the Report

Mechanically deboned poultry is the product resulting from the mechanical separation and removal from bone of the attached skeletal muscle tissue of poultry, with or without its skin and adhering fat. The product is called "boneless poultry" in the Code of Federal Regulations (In-1). The name "mechanically deboned poultry" is used in this report, although it is recognized that a decision may be made to propose a more descriptive name for the product.

MDP has been used in poultry and meat products in the United States since 1965. Potential problems of safety, such as bone content and possible additions of strontium-90 to the diet, were reviewed in 1964, and served as guides to rulemaking at that time. However, in the intervening years, scientific research has added considerably to our knowledge of the effects of various substances on nutrition and toxicology. The need to evaluate the health and safety aspects of use of mechanically processed (species) product (mechanically deboned meat) (In-2) focused attention of making a similar review of poultry.

Consequently, in November 1976, the Scientific and Technical Services of the Meat and Poultry Inspection Program (MPI) initiated a program to obtain data on a number of nutrients and potentially toxic substances in MDP as currently produced in commerce. Initially, sampling and analyses were made of MDP from cooked fowl frames (breast and

rib bones, with or without backs, from mature female chickens) and hand-deboned meat from the same birds. This class of poultry was chosen because it was expected to show the greatest exposure to potential hazards, since the possible toxicants of most concern--fluoride, lead, strontium-90, and chlorinated hydrocarbons--tend to deposit in bone marrow, to remain there, and therefore to increase with age. Use of cooked fowl frames would therefore provide data on mature female chickens (primarily spent layers); use of the frames rather than whole carcasses or whole anatomical parts would provide data on MDP in which bone-contributed constituents were least diluted by the presence of muscle.

The analytical program was later enlarged to include sampling of MDP prepared from raw broiler parts and raw turkey parts. These samples included product with and without skin, and with and without kidneys. Thus, it was possible to make some preliminary judgments as to whether or not there were species or class differences that could affect health and safety determinations, and whether contents of such potential toxicants as arsenic or cadmium could be affected by including or not including skin or kidneys. Analyses were made primarily by procedures used for MP(S)P (In-3). In a further addition to the analytical program, 200 samples of kidneys from broilers and mature fowl were acquired and analyzed for content of cadmium and lead, to determine if earlier detected cadmium or lead could have resulted from including kidneys in MDP. Also, data on cadmium and lead in kidneys from mature birds would make it possible to

calculate contents of these heavy metals in MDP from fowl with kidneys. Analytical samples of cooked fowl frames had not included kidneys.

In addition to the data obtained from this analytical program, data were gathered from the FSQS files and from the scientific literature. Some unpublished data were obtained from industry, government agencies, and university scientists. Data from the poultry industry, obtained by an ad hoc special research committee, were received after the first draft of this report had been completed, and are separately tabulated in the reports on bone particle size, cadmium, calcium, fluoride, lead, and iron. Unless otherwise indicated in the discussions on individual components of MDP, only results of the USDA analyses on MDP were used in estimating consumption of those components and in evaluating the healthfulness and safety of MDP for human use.

Poultry as discussed in this report includes young chickens (broiler-fryers), mature chickens (hens or fowl and roosters or stags), and young turkey. These types of poultry comprise nearly all of the poultry which is used in preparing MDP, and a large percentage of the poultry marketed in hand-deboned form. This report includes no data on old turkeys, ducks, or geese.

MDP is currently prepared in different ways, from different poultry parts and, as noted, from different species. The parts include necks, backs, frames, and whole carcasses; they may be raw or cooked; may be from young or mature birds; may contain varying amounts of muscle and/or skin; and may or may not contain kidneys. This evaluation is based on data from as many kinds of MDP as could be located, but includes only

very small samplings of some kinds of MDP. Additional data might be expected to modify slightly, but not to negate, the findings reported here.

For ease of reading, abbreviations have been used for certain terms in this report. "Mechanically Deboned Poultry" is designated as "MDP." "Mechanically Processed (Species) Product" is called "MP(S)P." To avoid confusion from too many sets of initials, the terms "beef MP(S)P" and "pork MP(S)P" have been used rather than the names established by regulation (In-4), namely "Mechanically Processed Beef Product" and "Mechanically Processed Pork Product." Standard abbreviations for metric units of measure have also been used.

In its task of evaluating MP(S)P, the MPI organized an interagency panel of scientists who were acknowledged experts in their fields. The panel submitted a final report, which formed a basis for the acceptance of MP(S)P, and also for limitations and/or requirements concerning its use.

It appeared desirable to again utilize the knowledge of the panel when the time came to evaluate health and safety aspects of mechanically deboned poultry. A similar, though less formal, approach was used. As data were gathered on each item of interest, a preliminary report was prepared by applying to the data the knowledge gained in evaluating MP(S)P. The report was then sent, for suggested revision or concurrence, to the panel member(s) who were expert in that particular field. Since the program had by then learned of a willingness of additional experts

to share their knowledge, these too were consulted in shaping the final report. FSQS is grateful to these and other key persons who provided the help necessary to complete this report. They are listed in Part VI.

Part II SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The effects on health and safety of use of mechanically deboned poultry (MDP) were evaluated. The kinds of MDP evaluated included raw and cooked parts, frames, (breast and rib bones, with or without backs), and carcasses from young chickens, mature chickens (fowl and stags), and turkeys. The data available at this time led to the following conclusions:

A. Arsenic in MDP poses no health hazards, whether products are prepared from young or older birds or from chickens or turkeys, and whether or not skin is included. The maximum arsenic content found in any sample was only about 20 percent of the tolerance level set by the Food and Drug Administration for poultry muscle.

B. Bone particles in MDP will not present any health hazard because of size or hardness, provided that bone particle size is controlled. Further work on the methods for extracting bone particles and determining bone particle size is advisable, in order to develop procedures suitable for routine monitoring.

C. Analyses for cadmium in broiler and fowl kidneys showed sharply greater cadmium contents in kidneys from the older birds. Calculations of maximum potential intakes of cadmium from MDP made from fowl backs with kidneys showed the possibility of a health risk for infants and relatively high cadmium intakes for children ages 6 to 12 years. This

high potential intake and risk could be made negligible by not allowing kidneys from mature chickens in MDP.

D. Calcium contents were lower in MDP than MP(S)P, which was found by a Select Panel on Health and Safety not to be a health hazard except possibly for the few persons who are hyper-absorbers of calcium. However, meat or poultry products containing MDP should be appropriately labeled so that the small percentage of the population which must limit calcium intakes for medical reasons would be alerted to the presence of increased calcium in the product.

Calcium-phosphorus ratios in MDP would confer only a slight, if any, nutritional benefit, as compared with calcium-phosphorus ratios in hand-deboned meat. Phosphorus content of MDP did not differ from content of hand-deboned poultry, and would present no health hazard.

E. In terms of fluoride content, there appear to be at least two types of MDP. One, made from fowl (mature female chickens), is similar to MP(S)P and should have the same use restrictions; i.e., limit use to 20 percent of the meat or poultry product portion of a product and prohibit use in strained, junior, and toddler foods. The second type of MDP, made from young chicken or turkey or mature male birds, contains only slightly more fluoride than hand-deboned poultry and needs no limits on use.

F. The amount of lead that would be added to the diet from use of MDP would be insignificant. There is no definitive evidence of real differences in lead content between MDP and hand-deboned chicken or

turkey. No restrictions on use level or use in products should be placed on MDP because of its lead content.

G. Selenium contents of MDP and hand-deboned poultry were similar. Therefore, substitution of MDP for hand-deboned poultry at any use level would not affect selenium content of diets, and MDP poses no health hazard from selenium.

H. MDP was much lower in strontium-90 content than was MP(S)P, which was found by the Select Panel to pose no health hazard because of strontium-90. Results were near the limits of detectability for the analyses, and could not be established to be different from background counts. Consumption estimates show that potential increased exposure to strontium-90 would be insignificant, even if MDP were used in products at a level of 100 percent of the poultry ingredient(s). Feeding of MDP to rats resulted in no increase in strontium-90 content of the rat bones, in comparison with feeding of hand-deboned poultry and with control diets. Therefore, MDP would pose no health hazard in terms of strontium-90.

I. Content of cobalt in MDP was indistinguishable from that in hand-deboned poultry. MDP would therefore present no health hazard at any use level in terms of cobalt content.

J. Copper content of MDP was within the normal limits for copper in muscle of poultry, and thus poses no health hazard for any use level of MDP.

K. Data on iron were variable, in some instances indicating that MDP contained less iron than did hand-deboned poultry, and in some instances indicating that it contained more iron. Variability was also found in bioavailability of iron from chicken and turkey, both hand-deboned and mechanically deboned. However, consumption data indicate that use of MDP would cause only small or negligible changes in iron intakes. It can therefore be concluded that iron from MDP poses no hazard to health. Use of MDP rather than hand-deboned chicken or turkey would probably have little effect on iron nutriture.

L. Nickel toxicity in humans via the oral route occurs only in extreme and unusual circumstances. MDP, if allowed in product at a rate of 100 percent of the poultry ingredient(s), could provide as much as 25 percent of the typical daily intake of 300 mcg. This amount is equivalent to a concentration in the diet of less than 0.6 percent of the proportion found to produce toxicity syptoms in toxicity studies. It can thus be concluded that nickel in MDP does not pose any health hazards.

M. Zinc content of MDP was similar to that of hand-deboned poultry. At current estimates of intake, even if present as 100 percent of the poultry ingredient(s) in formulated products, MDP would provide only small amounts of zinc to the diet. Zinc content of diets would be little affected by the presence or absence of MDP, and no restrictions on use of MDP are warranted because of zinc.

N. Amounts of chlorinated hydrocarbon residues did not differ between fat from MDP and fat from hand-deboned poultry. Residues were all well

within the established tolerance or action levels, and pose no hazard to health.

O. Cholesterol contents of different kinds of MDP were approximately double the contents in hand-deboned poultry flesh and were about the same as, or slightly higher than, poultry skin. However, daily increases in cholesterol consumption from use of MDP would be negligible on a per capita basis, and small for persons having 90th percentile intakes of MDP, and would not pose a health hazard for the general public. A small percentage of the population which has the hereditary condition known as familial Type II hypercholesterolemia must control cholesterol intake throughout life. For these persons, and for others who wish to restrict cholesterol intake, it is desirable to be able to identify products containing MDP. It is therefore recommended that foods containing MDP should be specifically labeled to show its presence.

MDP tended to be higher in total fat content than was hand-deboned poultry. It is recommended that fat content of MDP be restricted within the limits of good manufacturing practices.

P. Essential amino acid profiles were similar for MDP and hand-deboned poultry, and appeared to be completely adequate to meet nutritional needs of children or adults. Some MDP was found to contain more hydroxyproline, the amino acid found in collagen, than did hand-deboned poultry. However, protein quality, as measured by direct determination of Protein Efficiency Ratios (PER's), indicated that MDP, despite the presence of some collagen, can nearly always meet the PER of casein, a high-quality

protein. Because there are inadequate data of unequivocal standing to be assured of such protein quality, it is advisable to set a minimum standard for PER in MDP.

Total protein was lower, and moisture-protein ratios were much higher, in MDP than in hand-deboned poultry. The lower protein should not constitute a health hazard, in view of the fact that protein in diets of almost all Americans is high. However, the high moisture-protein ratios do raise questions as to whether or not MDP meets consumer expectations for poultry products. On this basis, consideration should be given to establishing minimum protein contents or maximum moisture-protein ratios for MDP.

Q. No differences were found between MDP and hand-deboned poultry in contents of total purines and of adenine, the purine which is known to increase blood uric acid levels. Hence, MDP presents no health hazard at any use level in terms of its purine content.

R. The microbiology of MDP was found not to present any unique problems. It appears, however, that handling and storage of starting materials is an important aspect. Current heat treatment requirements for ready-to-eat poultry items apply to products containing MDP. It is recommended that mandatory sanitary handling and storage of starting material be considered in any deliberation of regulatory needs, and that there be a clear understanding of the applicability of heat treatment requirements to ready-to-eat products containing MDP.

PART III. DETAILED REPORTS

A. Arsenic

Arsenic is the twentieth most abundant element in the earth's crust and is widely distributed in the environment, in soil, water, air, and all living creatures. All people are exposed daily to arsenic through the diet (A-1).

Most human foods including meats contain less than 0.5 mcg [1/] arsenic per gram of food, and rarely exceed 1 mcg per g on the fresh basis (A-2). Salt-water fish normally have a much higher level of arsenic than do fresh-water fish or domestic animals. In a summary from the National Research Council, data for arsenic in lobster ranged from 2.27 to 54.5 mcg per gram, cod fillet was reported to contain about 2.2 mcg arsenic per gram of tissue, and beef and pork to contain approximately 0.008 and 0.22 mcg arsenic per gram of tissue respectively (A-1).

Mahaffey et al. (A-3), using Fiscal Year (FY) 1973 data of the Food and Drug Administration (FDA), reported that the food group of meats, fish and poultry contained an average of 0.02 mcg of arsenic trioxide (.015 mcg of arsenic) per gram of food. Fiscal Year 1975 data from FDA (A-4) showed that chicken, with an average content of 0.084 mcg arsenic and a median content of 0.015 mcg arsenic per gram, was consumed in amounts large enough that it would provide about

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[1/] One gram (g) = 1,000 milligrams (mg) = 1,000,000 micrograms (mcg). One ounce = 28.4 grams.

5 percent of the daily dietary intake of arsenic. Chicken contained considerably less arsenic than did fish (which averaged more than 1 mcg arsenic per gram of fish) but more arsenic than did the beef, pork, eggs, or liver, analyzed by FDA. The FDA suggests that the higher arsenic levels in chicken may come partly from arsenic additives in poultry feed (A-4).

The extent to which arsenic is absorbed and retained in the body, and the route of its excretion, depend on how much and in what chemical form the arsenic is ingested (A-5). Arsenic, in the forms in which it ordinarily occurs in foods, is well absorbed and rapidly eliminated, mainly in the urine. The arsenic of organic compounds, including those such as arsanilic acid which are fed to animals for growth promoting reasons, is similarly well absorbed, disappears rapidly via excretion through the feces, and does not accumulate in tissue in excessive concentration (A-5). Inorganic forms of arsenic, such as arsenic trioxide, are also well absorbed, but are retained in greater amounts in tissues of man and rats than are organic forms (A-5).

Organic arsenic compounds are generally less toxic than the inorganic forms. Evidence of increasing recognition of the differences in toxicity between inorganic and organic arsenic was the 1975 proposal by the Occupational Safety and Health Administration to reduce permitted workplace exposure limits for inorganic arsenic to 4 mcg per cubic meter of air (8 hour, time-weighted average), while keeping in effect the previous standard of 500 mcg per cubic meter for organic forms of arsenic (A-6).

Arsenic has been used to alleviate selenium poisoning in pigs, dogs, chicks, and cattle (A-7). For this purpose, sodium arsenite and arsenate are equally effective, and organic forms of arsenic provide only partial protection.

In evaluating safety of use of mechanically deboned poultry (MDP) in terms of arsenic, the concern is whether man's total exposure will be significantly increased by use of MDP and, if so, whether the exposure will be of greater or lesser significance in terms of the type of arsenic.

Data on MDP and on hand deboned poultry are given in Table 1. No detectable amounts of arsenic were found in cooked fowl (mature hens) prepared by either processing method. Furthermore, although measurable amounts of arsenic were found in some samples of MDP from broilers and young turkeys, the maximum value found was only about 20 percent that of the tolerance level set by FDA of 0.5 mcg arsenic per gram of poultry muscle.

The presence or absence of skin in the MDP did not appear to affect arsenic content. Average arsenic content for MDP from broiler parts was 0.04 mcg per gram for product either with or without skin; ranges in values were from non-detectable amounts to 0.12 mcg per gram for broiler MDP with skin (20 samples) and from non-detectable amounts to 0.09 mcg per gram for broiler MDP without skin (10 samples). Similar comparisons for product from turkey showed average values of 0.03 and 0.02 mcg per gram respectively for product with skin (12 samples) and product without

skin (13 samples); ranges for both products were identical, from nondetectable amounts to 0.06 mcg per gram.

Data on arsenic in poultry muscle, obtained in 1976 as part of its regular monitoring program on residues by FSQS, showed maximum values of 0.15 to 0.20 mcg arsenic per gram of mature chicken and young turkey, and of 0.25 to 0.30 mcg per gram of young chicken. All of the maximum values for MDP (Table 1) were less than these maximum values for muscle. Therefore, use of MDP would not add to body burdens of arsenic.

The primary dietary exposure of poultry to arsenic is in the forms of arsanilic acid and 4-nitrophenylarsonic acid, which are added to feeds to improve growth, health and feed efficiency. The feeding of 3-nitro-4-hydroxyphenylarsonic acid to laying hens did not increase the muscle or bone values for arsenic over controls, although liver and feather values were elevated (A-8). Tests with arsanilic acid show that it is poorly absorbed, excreted rapidly and unchanged, and is completely eliminated by the bird's body within a few days after feeding is discontinued (A-9). The availability of arsanilic acid to a person eating tissue from an animal fed arsanilic acid in its feed was tested by feeding swine five times the normal dose (to obtain significant levels of arsenic in the liver) and then feeding the resultant liver tissue as part of the diet to chickens and rats. Results in the rat study show that the pig liver arsenic was rapidly excreted, primarily in the feces (A-10). In chickens, using activation analysis with a sensitivity

in the micrograms per kilogram range, a slight increase in chicken muscle arsenic was found with feeding of "pig liver arsenic" possibly because of the blood in the muscle. From these results, and from studies with radioactive arsanilic acid, the authors concluded that arsenic from this source was bound to protein and was metabolically inert (A-11). Thus, the very small amounts of unexcreted arsenic, if any, resulting from the feeding of arsenicals to poultry are so tightly bound in the tissue that they are essentially not available to the consumer, and do not add to his daily exposure to arsenic from foods.

Although inorganic arsenic has been described as being epidemiologically related to cancer and other abnormalities in man under conditions of prolonged high exposure (A-12), these same conditions have not been reported for the organic arsenicals. It is the organic arsenic compounds that are fed to poultry and that are thus the sources of arsenic residues in poultry tissues. As the amount of measurable arsenic in MDP is so small (no different from the amount found in poultry muscle), is in a form which is rapidly excreted, and does not appear to be metabolically available, it is virtually impossible that MDP could provide exposure to arsenic sufficient to cause abnormalities or health hazards. On the basis of these facts and the fact that arsenic contents of MDP are well below the tolerance level set by the Food and Drug Administration for arsenic in poultry muscle, it can be concluded that use of MDP as human food poses no public health problem because of arsenic.

B. Bone Particle Size and Hardness

Data on size of bone particles in MDP from cooked fowl frames showed a maximum size of 500 microns[1/] in the longest dimension (Table 2). For two of the eight samples analyzed, one percent of the particles were between 450 and 500 microns in length. In the other six samples, no particles were greater than 400 microns in their largest dimension. Ninety-one percent of the bone particles in MDP from cooked fowl frames were smaller than 150 microns--the maximum size of particle found in beef bone meal in an earlier USDA study (B-1). In comparison, beef MP(S)P had 50 percent of its bone particles with lengths of 150 microns or less (B-2).

Data on size of bone particles in MDP from raw chicken necks are also given in Table 2. For these samples, bone particles were even smaller than those of MDP from cooked fowl frames.

Unpublished data from the University of Nebraska (B-3) on bone particle sizes in turkey meat prepared by hand-deboning, sawing, and mechanical deboning showed maximum particle sizes larger than those found in USDA analyses for fowl and young chicken (Table 2). Maximum lengths were smaller in the turkey MDP than in hand-deboned turkey meat, and a larger percentage of bone particles from MDP than from hand-deboned or sawed turkey meat measured under 500 microns in length.

One or two of the bone particles in turkey MDP from the Nebraska study were considerably longer than the longest found in USDA samples.

1/ One centimeter = 10 millimeters = 10,000 microns.
One inch = 2.54 centimeters.

Both USDA and Nebraska analysts measured bone particles in material prepared in glycerine suspensions, and both groups noted instances of aggregating of smaller particles into a larger, easily dispersed particle. It is highly likely that most of the larger particle sizes noted by the Nebraska investigators are for aggregates. However, USDA had extracted bone particles from the MDP by an unpublished procedure involving the use of alcoholic potassium hydroxide, whereas extractions at Nebraska were made with papain, following the method of Hill and Hites (B-4). To determine whether the larger bone particles observed at Nebraska were characteristic of turkey as opposed to chicken or were due to the difference in extraction procedures, six additional samples of turkey MDP and one of chicken MDP were obtained and extracted by both procedures by USDA analysts. Table 3 summarizes results of the subsequent particle length measurements for these samples.

Results in Table 3 indicate that turkey differs little from chicken in bone particle size. Both chicken and turkey MDP represented in Table 3 had a few bone particles larger than the chicken MDP samples reported in Table 2. Table 3 also shows that samples extracted by papain had a slightly greater percentage of particles in all size intervals larger than 212 microns than did samples extracted by alcoholic potassium hydroxide. The percentage of bone particles 500 microns or less averaged 97 for samples extracted by alcoholic potassium hydroxide, and 94 for samples extracted by papain. In contrast, all particles reported in Table 2 for MDP from chicken necks and fowl frames were 500 microns or less. Most of the larger bone particles from papain

extraction, when viewed under high magnification, were seen to consist of particles of hard bone joined by connective tissue. These agglomerates readily dispersed when a slight pressure was applied.

Samples of turkey MDP were also evaluated by poultry scientists at the University of Nebraska, following extraction with alcoholic potassium hydroxide or with papain (B-5). These researchers also found agglomerates of hard bone and connective tissue, using the papain method. They further reported that time of heating of the sample in alcoholic potassium hydroxide could affect size of the extracted bone particles. In their opinion, the alcoholic potassium hydroxide method should be standardized before being used for regulatory purposes.

Data evaluated for this report were obtained from samples of MDP prepared using auger-type deboning equipment from two manufacturers. Some equipment currently available has larger orifices than do these two makes. Therefore, conclusions reported here may not apply to all MDP currently produced. Further studies are needed to determine maximum particle size of product from other machines. In particular, information on press-type machines would be useful. Use of press-type machines results in a product low in calcium, but no data are available to help in determining safety of the bone particle size. It would be inadvisable to encourage the use of MDP with lower calcium content than currently attained if the reduced calcium were accompanied by bone particle sizes that would raise questions concerning safety.

An unpublished report from Michigan State University (B-6) provides information on histological examinations of tissues from the stomach, small intestine, and colon of growing male rats fed MDP and hand-deboned poultry. No bone fragments were found in tissues from either group. The authors concluded that bone particles in MDP are solubilized under physiological conditions and that the resultant minerals are available for absorption. They found no evidence that bone particles damaged gastrointestinal tissues.

At the request of USDA, a review of possible health hazards associated with hardness of bone particles in MDP was made by the staff of the Americal Dental Association Health Foundation (B-7). They reported that a computer-assisted search of the dental literature for the United States and the world produced no evidence of any findings of untoward reactions related to bone particles in MDP. Laboratory staff personnel at medical schools, dental clinicians, dental school staffs, and dentists in private practice were also consulted and reported no known problems with bone particles in MDP. The report of the Foundation concludes:

> "If one assumes that the beef, fowl frame, chicken, and turkey specimens are representative of what might be encountered in normal production, then there would seem to be no cause for concern about mechanical intraoral reactions. No such problems are reported in the literature. Dental scientists do not believe a problem exists or could occur with such materials. If a problem did exist, it probably would have occurred with meats deboned by hand where bone chips might have been larger."

While particle size must be controlled, neither size nor hardness of bone particles in MDP present any health hazard. This conclusion is supported by (1) a comparison to bone particles encountered in MP(S)P, which had earlier been judged safe by the Select Panel on the Health and Safety Aspects of the Use of Mechanically Deboned Meat, (2) 14 years of production of MDP with no evidence of ill effects, (3) the work at Michigan State University demonstrating that the particles are solubilized under physiological conditions, and evidencing no damage to gastrointestinal tissues, and (4) the report of the American Dental Association Health Foundation.

To ensure that equipment type or processing does not result in unacceptably large bone fragments in MDP, bone particle size in MDP should be controlled. In addition, further work on the methods for extracting bone particles and determining bone particle size is advisable, in order to develop procedures suitable for routine monitoring. The standard set for maximum bone particle length could depend in part on the method of analysis adopted for monitoring.

C. Cadmium

As shown in Table 4, cadmium was present in some samples of MDP from cooked fowl frames and of hand-deboned fowl in detectable (0.01 ppm or greater) amounts. These samples were therefore higher in cadmium than were beef or pork MP(S)P, which were not found in any case to contain measurable amounts of cadmium.

Because of the possibility that the small amounts of cadmium in these samples might have come from kidneys, six samples of MDP prepared from young chicken (broiler) parts with kidneys were analyzed for cadmium. In no case were detectable amounts of cadmium found. In 23 samples of MDP from broiler parts without kidneys, 21 contained no detectable amounts of cadmium, and two contained 0.02 mcg cadmium per g of product. In addition, cadmium analyses were made on 23 samples of MDP prepared from turkey parts without kidneys. Results showed one value of 0.02 mcg cadmium per g of product, one value of 0.01 mcg per g, and the remaining 21 samples containing no detectable amounts of cadmium.

To further investigate the role of kidneys in contributing to cadmium content of MDP, 100 samples each of kidneys from broilers and from fowl (mature hens) were obtained and analyzed for cadmium. Each sample consisted of kidneys from 10 birds. Results showed sharp increases in cadmium content of kidneys with age; in fact, the low value for cadmium in kidneys from fowl, 0.16 mcg per g, was about equal to the high value found in kidneys from young chicken (broilers) of 0.18 mcg per g (Table 4). The average value for cadmium in fowl kidneys was

16 times higher than the average value of 0.05 mcg per g for broiler kidneys. These results indicate that kidneys could contribute cadmium to MDP made from fowl in amounts great enough to be of significance in assessing healthfulness of the product.

The current estimate of the Food and Drug Administration for average daily intakes of cadmium is 57 mcg (C-1). This estimate is at the low end of the FAO-WHO's proposed range for tolerable daily intakes of 57 to 71 mcg (C-2), and indicates that it would be prudent not to allow new increases in the cadmium content of foods.

The highest value found in FDA's recent study for cadmium in raw agricultural products was 0.092 mcg per g of soybeans (C-1). This amount is little more than 10 percent of the mean value found for kidneys from fowl, and also is less than the 90th percentile value of 0.10 mcg per g found for cadmium in broiler kidneys. On the dry weight basis, differences in cadmium content among the three products could be even greater, as kidneys contain roughly 75 percent water compared with 10 percent water in mature raw soybeans. Average cadmium contents per g of dry weight would be 3.2 mcg, 0.2 mcg, and 0.1 mcg respectively for fowl kidneys, broiler kidneys, and soybeans. Kidneys from fowl are thus clearly high in cadmium compared with other ingredients used in human foods. Broiler kidneys could also be considered an important source of cadmium.

Cadmium contents of MDP made from backs including kidneys from broilers and from fowl were calculated, and dietary consumption estimates were made, using these calculated values. MDP from backs was used because kidneys are associated with the back rather than with other

anatomical areas of poultry, and because poultry backs are a major source of material for the preparation of MDP. Kidneys represent approximately 0.5 percent of the body weight of poultry and would comprise about 4 to 6 percent of the backs used in preparing MDP (C-3). The yield of MDP is usually in the range of 50 to 70 percent of the starting product (C-3). It is to be expected that all of the kidney, a soft tissue, would be found in the MDP after preparation.

Results of the calculations are shown in Appendix Table VI-1. These results showed MDP from raw broiler backs including kidney to have an average content of 0.004 mcg and an upper-limit content of 0.009 mcg of cadmium per gram of MDP. These values were in good agreement with data from analyses for cadmium in MDP from raw chicken parts (Table 4). Also, the estimated average was equivalent to the lowest value found by the FDA in raw agricultural products, namely apples, which contained 0.003 mcg of cadmium per gram (C-1). However, the calculated values for cadmium in MDP from raw fowl backs including kidneys, averaging 0.096 mcg of cadmium per gram of MDP and having an upper limit of 0.244 mcg of cadmium per gram of MDP, were very high compared with amounts of cadmium (average, less than 0.01 mcg per g; maximum, 0.02 mcg per g) found by analysis of cooked fowl frames (Table 4). The calculated average content of MDP from raw fowl backs with kidneys equalled, and the upper limit far exceeded, the highest value found by the FDA (0.092 mcg per g) for cadmium in raw agricultural products (C-1).

To help in evaluating the effects of cadmium in MDP on daily intakes of cadmium, estimates of cadmium consumption were made. It should be

noted that problems are encountered in trying to estimate consumption with data presently available. For instance, food consumption values used in the evaluation of MP(S)P were based on data from the 1965 Household Food Consumption Survey of the USDA (C-4). At that time, few if any products containing MDP were marketed. Since MDP has been used in many products which were unknown in 1965 (chicken franks, turkey bologna), it would be more difficult to estimate consumption of MDP than to project consumption of MP(S)P. In addition, there are no production data on poultry sausages, so it is not possible to estimate consumption by using information on MDP-containing products available for consumption. Estimates of increased cadmium consumption were therefore made using several different approaches.

Consumption of cadmium from poultry, with and without MDP, was first calculated, using data on current production and per capita supplies of poultry. Calculations are given in Appendix Table VII-1 and VII-2. These calculations assume that 85 percent of poultry supplies were in ready-to-cook form, 15 percent were further processed (C-5), the proportions of young chicken, mature chicken, and turkey were as given in Appendix Table V-1, and all "further processed" poultry was MDP. Use of MDP would result in an increased consumption of 0.25 mcg of cadmium per person per day, or 0.4 percent of the FAO-WHO acceptable daily intake of 57 mcg. This per capita calculation shows that MDP as currently prepared, including product from fowl with kidneys in natural proportions, currently presents little, if any, health hazard to adults, on the average.

Intake of cadmium from MDP by infants, with their smaller body weights, could present problems of safety not apparent from per capita data for adults. Therefore, estimated intakes of cadmium were calculated using data that were provided by the food industry through the National Food Processors Association (C-6) on consumption of poultry-containing foods by infants. Surveyed infants who ate poultry products ranged in age from 2 to nearly 14 months, average 7.6 months, and ate from one to five different kinds of poultry products during the 4-day period in which their diets were recorded. Poultry products ranged in estimated content of cooked poultry ingredients from 3 percent to 57 percent of all ingredients. Data were separately calculated for projected chicken intakes of each infant, and from these individual intakes, median and 90th percentile intakes of chicken were calculated. Data for average intakes of chicken were not used in these calculations because the consumption data showed a skewed distribution.

Table 5 summarizes results of these calculations, giving data for the years 1972, 1974, and 1977 for amounts of chicken ingredients consumed, and the amounts of cadmium that would be contributed to the daily diet, if all of the chicken ingredients were cooked MDP from fowl with kidneys in natural proportions and the calculated cadmium content of the MDP were 0.137 and 0.349 mcg per gram of MDP for average - and 90th percentile-cadmium levels respectively (see Table 4).

Projected cadmium intakes given in Table 5 are high for both median and 90th percentile intakes, with either average or 90th percentile contents of cadmium in the MDP; they ranged from 0.30 to 4.71 mcg per day.

For a 6- to 7-month child weighing approximately 8 kg (C-7), these daily intakes would range from 0.04 to 0.59 mcg per kg of body weight. These projected intakes would be 4 to 62 percent of the current guideline for acceptable daily intakes per kg of body weight, which is 0.95 mcg and was used in earlier evaluations of the safety of mechanically deboned meat (mechanically processed (species) product) (C-8).

The data in Table 5 are undoubtedly high, because food consumption data were not adjusted for frequency of intake, cadmium contents of poultry products were calculated at high expected concentrations, and MDP contents of poultry products were estimated at maximum levels. There is no reason to expect that baby foods containing poultry present an unacceptable risk from cadmium at present. Nevertheless, the possibility of a health risk remains, and this risk could be made negligible by not allowing MDP used in baby foods to be made with mature chickens containing kidneys.

Cadmium consumption from MDP was estimated (see Appendix Table IX-1) for all age groups assuming the same intakes of MDP as were assumed for MP(S)P (C-8), and using the average and maximum values calculated for MDP made with cooked fowl containing kidneys (0.137 and 0.349 mcg per g, respectively). Daily consumption values per kg of body weight were found to range from 0.018 mcg for adults 45 years and over, to 0.109 for children ages 3 to 12, when the cadmium content of MDP was 0.137 mcg per g, and from 0.045 for adults 45 years and over to 0.253 for children ages 6 to 12 and 0.268 for infants 0 to 2 years when the cadmium content of the MDP was the calculated 90th percentile

value of 0.349 mcg per g. The estimated cadmium consumption for children ages 6 to 12 would be 5 to 27 percent of the tolerable daily intake of 0.95 mcg per kg of body weight.

Market basket data from the Food and Drug Administration (C-9) indicate that less than 5 percent of total daily intake of cadmium comes from meat, fish, and poultry (including liver, a major source of cadmium in the meat group, but not including kidney). This is in contrast to nearly 23 percent coming from grains and cereals; 18 percent from potatoes; and 18 percent from fruits. (Data for Fiscal Year 1973). It is not known whether or not products containing mechanically deboned poultry made from fowl with kidneys were included in the foods comprising the meat, fish, and poultry group.

As reported above, intakes of cadmium from use of MDP made from fowl with kidneys were projected to range from 5 to 82 percent of the acceptable daily intake (ADI) for infants, and from 5 to 27 percent of the ADI for children ages 6 to 12. These amounts are excessive for a food group which provides overall only 5 percent of the average daily body burden of cadmium. Therefore, it is recommended that kidneys from mature chickens not be allowed in MDP prepared for use in human foods.

D. Calcium and Phosphorus

Data obtained by USDA on calcium content of MDP from cooked fowl frames and comparable hand-deboned fowl are reported in Table 6, along with data obtained from published and unpublished sources on calcium in MDP and USDA data on calcium in beef and pork MP(S)P.

Additional data on calcium content of MDP, primarily obtained from the poultry industry through the Special Poultry Research Committee (D-1), are summarized in Table 7. Also given in Table 7 are calcium values for raw and cooked hand-deboned light meat, dark meat, and skin of chicken and turkey. These data on hand-deboned poultry are the best current estimates of calcium content of edible tissues from young chicken and turkey (D-2).

Calcium data for MDP shown in Table 7 were generally in good agreement with data for comparable samples in Table 6. Average calcium contents of MDP from raw and cooked fowl frames and cooked fowl carcasses were about equal to maximum calcium contents of MDP prepared from young chickens or turkeys. Average contents of calcium (Table 7), were considerably lower for hand-deboned poultry meat or skin than for MDP.

Calcium values in Tables 6 and 7 were obtained on samples prepared in auger-type machines, which require some preliminary grinding or breaking of starting material. Another type of mechanical deboner, the press-type, works on the principal of reducing starting material to the least volume, and does not require prebreaking or pregrinding

of the bone. Calcium values on four samples of MDP prepared from this type of machine ranged from 0.03 to 0.07 percent (D-3). These values are close to the lowest values obtained using auger-type machines, as shown in Tables 6 and 7, and indicate that the press-type machine may remove more bone in the preparation of MDP than do auger-type machines. However, as previously pointed out, it is believed that bone particles are larger than those from auger-type machines, although data are not available on particle size of bone.

Cooked fowl frames contained more calcium than any other kind of poultry processed through mechanical deboners. Therefore, if they were found to present no health hazard from calcium, other forms of MDP should likewise not be a health hazard in terms of calcium.

Beef MP(S)P was found to contain average and 90th percentile contents of calcium of 0.59 and 0.86 percent respectively (D-4). Corresponding values for pork MP(S)P were 0.41 and 0.69 percent.
The Select Panel reviewing mechanically deboned meat (MP(S)P) concluded that calcium which would be added to the diet by this product is not so great in amount as to pose a hazard to the health of most people, except for those persons who are hyper-absorbers of calcium and likely already to be under medical supervision to limit their calcium intake (D-5). Mechanically deboned cooked fowl frames, with a calcium content that is about half that of the product from red meat animals, would likewise pose no health hazard to most people.

Health and safety evaluations for calcium in MP(S)P were based on products containing MP(S)P in amounts no more than 20 percent of the total meat, meat byproducts, or poultry products portion of foods (D-5). However, many poultry products have been marketed in which MDP makes up 100 percent of the total poultry or poultry products ingredients. This high a proportion could provide a final product with higher calcium contents than those products projected to contain 20 percent MP(S)P. Effects of usage of MDP at 100 percent levels were therefore evaluated as follows:

MDP from cooked fowl frames, with a 90th percentile calcium content of 0.28 percent, contains less than half the calcium of beef MP(S)P (90th percentile content of calcium was 0.86 percent) or pork MP(S)P (90th percentile content of calcium was 0.69 percent) (D-4). When used as 100 percent of poultry ingredients, it would provide at most twice the calcium projected to be added to diets by use of MP(S)P. Maximum increased calcium from MP(S)P was estimated to range from 16 mg per day for babies 0-2 years in age to 54 mg per day for adults 18-24 years (D-5). If MDP provided double these amounts of calcium, or 32 to 108 mg calcium per day, the increase would be only a small fraction of the Recommended Dietary Allowances (RDA's) of 360 to 1,200 mg per day for persons of different age-sex groups (D-6).

Calculations of the per capita consumption of calcium from MDP were made in the same way as was done for cadmium, and are shown in Appendix Tables VII-1 and VII-2. Results showed a per capita daily consumption of calcium from hand-deboned poultry of 7.6 mg. If all

processed poultry were MDP, the calcium consumption would be 17.7 mg. The daily increase in per capita consumption of calcium would be 10.1 mg. This amount would be approximately 1 percent of the RDA for adults of 800 mg.

These small projected intakes of calcium from MDP represent negligible increases in the daily calcium intake and cannot be considered hazardous, especially to the large sector of the population which may not consume an optimum or adequate intake of calcium. However, meat or poultry products containing MDP should be appropriately labeled so that the small percentage of the population which requires low calcium intakes for medical reasons would be alerted to the presence of increased calcium in the product.

Calcium:phosphorus ratios in MDP from cooked fowl frames averaged 1.21, with a range from 0.74 to 1.75. Those values in every case exceeded calcium:phosphorus ratios for hand-deboned cooked fowl, for which ratios ranged from 0.16 to 0.51, with a mean of 0.26. The calcium:phosphorus ratios in the MDP from cooked fowl frames more closely approached the ratio of 1, which is considered desirable by many nutritionists, and which formed the basis for establishing the Recommended Dietary Allowance for phosphorus (D-6), than did the ratios for hand-deboned fowl. However, the body can tolerate a wide variation in the calcium:phosphorus ratio, provided the amount of vitamin D in the diet is adequate (D-6). Thus, the higher calcium:phosphorus ratios in MDP from cooked fowl frames could be judged to confer only a slight nutritional benefit.

Data on calcium:phosphorus ratios in other kinds of MDP were not available for this review. However, they could be expected to resemble more closely ratios from hand-deboned poultry than from MDP from cooked fowl frames, in view of the lower calcium contents of these products (see Table 6).

Phosphorus contents of hand-deboned cooked fowl and MDP from cooked fowl frames were in close agreement, averaging 0.16 to 0.17 percent respectively. Ranges were 0.14 to 0.22 percent for the hand-deboned fowl and 0.13 to 0.23 percent for the MDP. No hazard to health would be posed by the phosphorus content of MDP.

E. Fluoride

Contents of fluoride in MDP, hand-deboned poultry, and MP(S)P made from beef and pork are given in Table 8. MDP made from cooked frames from fowl (mature female chickens) contained considerably more fluoride than MDP made from raw young chicken parts or raw turkey parts, and slightly more fluoride than was found in MP(S)P made from pork. MDP made from cooked fowl frames was slightly lower in fluoride than was MP(S)P made from beef.

MDP made from young chicken parts or turkey parts contained only about 2 mcg of fluoride per gram, an amount only slightly higher than the amounts of fluoride found in hand-deboned young chicken of 0.2 to 1.0 mcg per gram (Table 8). The amount found is similar to the amount in brewed tea, which has been found to average 2.18 mcg fluoride per gram of beverage (E-1).

Data on fluoride content of 11 kinds of MDP are given in Table 9 along with data on fluoride in hand-deboned poultry and in baby foods. These data were obtained from the poultry industry (E-2, E-3), unpublished academic sources (E-4, E-5) and the scientific literature (E-6, (E-7). As was observed for data in Table 8, MDP made from young chickens and turkeys contained only slightly more fluoride per gram of product than did hand-deboned poultry. Fluoride values for MDP from parts and carcasses from stags (mature male birds) were similar to fluoride data obtained on MDP made from young chicken and turkey. In contrast, fluoride contents of MDP made from fowl were high, whether the MDP came from

raw or cooked frames or from whole cooked carcasses. These data for fluoride in MDP from fowl are in excellent agreement with data on cooked fowl frames given in Table 8.

The greater content of fluoride in MDP from old female chickens than from old males may be caused by the more active mineral metabolism in bones of female chickens producing eggs. When calcium is lost from bone for eggshell formation, absorption of dietary calcium increases, and an increased fluoride absorption may accompany the increased calcium absorption. This fluoride, once incorporated into the bone, is highly unlikely to be removed, and thus accumulates. An expert on mineral metabolism of poultry bone (E-8), when consulted about this possible explanation, stated that it was plausible, but that he knew of no scientific reports dealing with this aspect of mineral metabolism.

Data in Table 9 for baby foods, obtained in three different laboratories, show variable amounts of fluoride. The high fluoride contents of some of the chicken products for babies suggest that some mechanically deboned fowl may have been used in their preparation.

When fluoride data for three kinds of MDP--raw broiler backs, cooked fowl frames, and raw frames from young turkeys--were summarized by geographical source, it was evident that age of animal rather than geographical source was the predominant factor in determining fluoride content (Table 10). Poultry feeds also can play a role in the fluoride content of MDP because of the fluoride content of the source of phosphorus added to the feeds. Froning (E-4) fed experimental rations containing high-fluoride (2.42 and 2.65 percent) phosphate sources to young turkeys, and

prepared MDP from the raw necks when the turkeys were 20 weeks old. He found an average of 22 mcg fluoride per gram of the MDP, as compared with 1.2 mcg fluoride per gram of MDP from turkeys whose rations included phosphate sources with fluoride contents of 0.23 percent or less. The Food and Drug Administration exercises strict control over the content of poultry feeds, and does not allow use of high-fluoride phosphates. It is not likely any change in the fluoride levels of the feeds will take place. However, if changes do occur, the USDA would be notified and appropriate monitoring of MDP for fluoride content would be undertaken.

The fluoride value which was a major basis for the evaluation of MP(S)P for safety of fluoride content was the 90th percentile value of 27.80 mcg fluoride per gram of MP(S)P made from beef (E-9). In comparison, the 90th percentile value for fluoride in MDP from cooked fowl frames analyzed by USDA was 23.51 mcg per g. None of the USDA values for fluoride in cooked fowl frames exceeded the 90th percentile value for beef, and it was exceeded by only six of the 46 values submitted by the Special Poultry Research Committee for fluoride in MDP from fowl frames or carcasses. The maximum value for fluoride in MP(S)P, 34.4 mcg per g, (E-10) was equalled or exceeded by only two values, 34.4 and 43.8 mcg fluoride per g, in MDP.

To estimate fluoride that would be added to the diet by use of MDP, calculations similar to those for cadmium and calcium were made. These calculations, which are shown in Appendix Table VII-1 and VII-2, indicate that per capita consumption of fluoride from poultry would be 75 mcg per day, if all processed poultry (15 percent of total poultry) were MDP.

This would be an increase of 35 mcg of fluoride over the amount contributed by poultry containing no MDP (41 mcg per day). This increase, 35 mcg, is 7 percent of the recommended daily intake of 0.5 mg (500 mcg) suggested as desirable for infants and children up to 3 years of age, and less than 4 percent of the recommended daily intake of 1.0 mg (1000 mcg) per day for those over 3 years of age (E-11). These estimated intakes may be high as they assume a high intake of MDP in proportion to total poultry consumed. Estimates of intakes by infants and children may be further overstated by assuming an intake of total poultry equal to the per capita disappearance figures, whereas consumption of poultry by infants would probably be much smaller than that by adults or adolescents.

For adults and adolescents, detrimental effects of fluoride ingestion do not appear with intakes of 5 mg (5000 mcg) or less daily (E-11). Thus, intakes up to five times the recommended amount are safe. San Filippo and Battistone (E-12) determined fluoride on four "market basket" samples--collections of food typical of intakes of 16- to 19-year-old males--from Baltimore in 1967 and 1968. They found average daily fluoride contents of 2.09 to 2.34 mg, with beverages providing about two-thirds of the total. Baltimore's water supply is fluoridated to a concentration of 1 ppm; for diets in non-fluoridated cities, fluoride contents might be lower. These data demonstrate a comfortable margin between estimated intakes of fluoride by a high-consumption age group, and an estimated maximum safe intake, and indicate that intakes of fluoride from MDP, even in excess of those estimated using per capita disappearance data, would be highly unlikely to pose any health or safety problems for adults or adolescents.

Consumption of fluoride by infants was calculated, using data provided through the National Food Processors Association (E-13) for consumption of poultry products by infants as determined by surveys in 1972, 1974, and 1977. Calculations assumed that all poultry came from MDP which contained 90th percentile amounts of fluoride. When median (50th percentile) amounts of poultry were consumed by infants, intakes of fluoride from MDP, if made with young chickens and turkeys, were low--less than 5 percent of the acceptable daily intake (ADI) of 500 mcg (Table 11). MDP from young poultry used at high consumption rates (90th percentile) would provide from 8 to 11 percent of the ADI for fluoride. Because these data were not adjusted for frequency of consumption, they can be expected to overestimate consumption somewhat. However, intakes of fluoride from MDP made with fowl were about 5 times greater than intakes of fluoride from MDP made with young poultry, and at 90th percentile poultry intakes provided 40 to 56 percent of the ADI. This is an excessive amount to be provided by one food.

A further estimate of consumption of fluoride by infants was made using data from the USDA Household Food Consumption Survey of 1965, adjusted for frequency of eating, as developed for a health and safety review of MP(S)P (E-14). These data indicate a 90th percentile consumption of 9.4 grams of meat per day. If all of that meat were MDP from broilers, turkeys, or roosters, and contained 3.8 mcg fluoride per gram of product, the fluoride contribution to the total daily intake would be 36 mcg per day. If all of the meat were MDP from fowl containing 23.5 mcg fluoride per gram (90th percentile content), the fluoride intake

from MDP would be 221 mcg per day. The lesser amount (36 mcg) is somewhat lower than calculated intakes reported in Table 11 for MDP from young chicken and turkey. It is about half of the estimates based on per capita food supplies reported above.

Wiatrowski et al. (E-7) estimated fluoride intakes of infants 4 to 6 months to be 1.23 mg per day, or 0.16 mg per kilogram body weight per day. In estimating these intakes, they assumed that 130 grams of meat containing 0.9 mcg fluoride per gram of meat was consumed. This amount of meat is considerably greater than consumption of poultry for infants as reported in Table 11. Singer and Ophaug (E-6) estimated fluoride intakes to range from 153 to 763 mcg per day for infants 6 months of age receiving meat and poultry in their diets; most of the fluoride was indicated as coming from formula.

Forsman (E-15) investigated dental fluorosis in 1,094 Swedish children having different fluoride intakes. She found that children living in areas with water containing up to 1.5 mg fluoride per liter exhibited only mild fluorosis--if any--that could be detected only through careful observation by a trained observer, and in many cases had not even been observed by the dentists treating these children. Intakes of fluoride for babies ages 2.5 months or less, who in later years fell in these observation groups, were from less than 0.1 to 0.29 mg per kg of body weight. This maximum, 0.29 mg of fluoride per kg of body weight per day, is considerably higher than the intakes of 0.16 and 0.127 mg of fluoride per kg of body weight found by Wiatrowski (E-7) and Singer (E-6) respectively for infants 6 months of age. Thus, there appears to be a wide margin of safety between usual intakes of fluoride by babies in this country and

intake levels above which fluoride-induced mottling of teeth might be expected. A safe upper limit for fluoride consumption for babies of 6 months in age would be 0.2 mg per kg of body weight, according to Spencer (E-16). For a 7-month-old child weighing approximately 8 kg (E-17), this amount would be 1.6 mg (1600 mcg) per day.

Upper limits on fluoride consumption for infants averaging nearly 8 months in age as shown in Table 11 indicate that MDP from young chicken and turkey would provide about 3 to 4 percent of the estimated maximum acceptable intake of 1600 mcg. However, there is almost no likelihood that a baby would consume this amount daily, as the data were not adjusted for frequency of consumption. It can therefore be concluded that MDP made from young chicken or turkeys would provide no health hazard to infants, even if used as 100 percent of the poultry or poultry products ingredients in the baby food. In contrast, upper limit intakes for fluoride from MDP made with fowl could easily provide more than half of the recommended intakes of 500 mcg, and nearly one fifth of the estimated maximum acceptable intake. Average consumption of fluoride from MDP made with fowl would be greater than 90th percentile consumption of fluoride from young chicken MDP. Even if adjusted for frequency of consumption, intakes of fluoride from MDP from fowl would provide large proportions of the total day's consumption. In view of the current lack of information on fluoride intakes of infants in high-fluoride areas, and following the principles for use developed for MP(S)P, it can be concluded that MDP from fowl should not be allowed in baby foods, and should be restricted to no more than 20 percent of the poultry or poultry products ingredients of other foods.

It is therefore recommended that use of MDP from fowl be prohibited in baby (strained), junior, and toddler foods; that use of MDP from fowl be limited to 20 percent of the poultry and poultry product portion of other poultry food products; and that combined use of MP(S)P and MDP from fowl be limited to 20 percent of the meat, meat byproducts, poultry, and poultry products portion of meat food products. However, MDP prepared from roosters or young chicken or turkey is a different product from MDP prepared from fowl in terms of fluoride content, and requires no limitations of use for reasons of health.

F. Lead

Adverse health effects produced by lead, quantities of lead producing these effects, and the amount of lead currently present in the food supply were discussed in the final report of the Select Panel on Health and Safety Aspects of the Use of Mechanically Deboned Meat (F-1), and will not be further reviewed here. The Panel's evaluation of lead in MP(S)P stated, ". . . using even the most extreme assumptions on consumption of mechanically deboned meat, the amounts of lead added by mechanically deboned meat are hard to document as an addition of lead to the diet. Relative to the magnitude of other environmental sources of lead for children, the amount of lead from mechanically deboned meat is toxicologically insignificant." (F-1).

As shown in Table 12, MDP made from cooked fowl frames was similar in lead content to MP(S)P. MDP prepared from raw chicken or turkey parts was even lower in lead, and did not appear to be different in lead content from hand-deboned poultry.

Additional data on lead contents of MDP and hand-deboned poultry, provided by the Special Poultry Research Committee (F-2), are given in Table 13. These data, like the USDA data, were low, and many values were below the level of detectability. The data in Table 13 did not indicate any differences in lead content between young and old poultry, or between MDP prepared from frames and that prepared from parts. Furthermore, the few data for lead in hand-deboned fowl and turkey which are given in Table 13 were no lower in average values than were MDP

values. Untabulated data from Michigan State University (F-3) showed no detectable amounts of lead in either hand-deboned or mechanically deboned chicken.

Difficulties are encountered in determining lead present in concentrations close to the limit of detectability. Lead data from industry indicated that at least two limits--0.01 and 0.1 mcg per gram--were involved in the analytical procedures used by the laboratories. Thus, the assembled lead data for MDP provide no definitive evidence of any real differences in lead content between MDP and hand-deboned poultry.

Kidneys from old chickens did not differ from cooked fowl frames in terms of lead content, and hence would not contribute any additional lead to the product if not removed prior to mechanical deboning. However, kidneys from young chickens did appear to contain slightly higher levels of lead than did MDP from raw chicken parts. Using average and maximum values for lead in young chicken kidneys, calculations were made of the estimated lead content of MDP from raw broiler backs with kidneys. Calculations were made in the same way as those made for cadmium (Section C of this report), and assumed a yield of MDP of 50 percent. Results (Table 12) show estimated lead contents that are not measurably higher than lead in MP(S)P, which was judged by an expert panel to pose no hazard in terms of lead content (F-1). From the standpoint of possible increases in lead content of MDP, there would be no reason to prohibit kidneys.

Estimates of consumption of lead from MDP were made in an attempt to describe the maximum possible change in lead consumption that could

result from use of MDP. Per capita lead consumption was estimated as shown in Appendix Table VII-1 and VII-2. Following the general pattern of other consumption calculations in this report, only USDA data for lead contents of MDP and hand-deboned poultry were used in the computations. In this way, the effects of analytical error and sampling procedures were minimized. According to these calculations, use of MDP would not increase per capita consumption of lead; without MDP, poultry would provide 0.92 mcg of lead per day per person; with MDP, poultry would provide 0.90 mcg of lead per day per person. Tolerable daily intakes of lead range from 100 mcg per day for infants under 6 months of age to 429 mcg per day for adults (F-1). The amount of lead provided by poultry with or without MDP would be only 0.9 percent and 0.2 percent of the tolerable daily intake for infants and adults respectively.

Consumption of lead from MDP was also estimated by use of consumption estimates for MP(S)P (F-4). Data for projected intakes of lead in MP(S)P and MDP at 20 percent levels of use in product, MDP at 100 percent levels of use in product, and hand-deboned poultry which would be replaced by MDP, are given in Table 14 for children ages 0 to 2 years, 3 to 5 years, and 6 to 12 years. These data are for 90th percentile intakes of MP(S)P and MDP from cooked fowl frames with 90th percentile lead contents; for hand-deboned poultry, values are for 90th percentile intakes of cooked fowl having an average lead content. These data show that amounts of lead in products containing MDP from fowl could be roughly six times the intake of lead from the poultry ingredient replaced by MDP. The maximum increases were estimated to range from

0.2 to 0.5 mcg per day at the 20 percent level of usage, and from 0.9 to 2.4 mcg per day at the 100 percent level of usage. Such increases amount to 0.2 percent of the provisional tolerable daily intakes for children in these age groups at the 20 percent usage level, and 0.6 to 1.0 percent at the 100 percent usage level. It should be emphasized that these estimated increases in intakes, which are small, would be for the top 1 percent in consumption and that average consumption increases would be much lower; also, that use of a different kind of MDP (broiler or turkey) would probably result in smaller or no increases.

Estimated maximum intakes of lead from MDP (cooked fowl frames) are about the same as intakes from MP(S)P, if MDP is used as 20 percent of the poultry ingredient (Table 14). Since lead content of MP(S)P at the 20 percent usage level was found to pose no problems in terms of health and safety, it can be concluded that MDP used at the 20 percent usage level would also pose no problems. MDP from raw chicken parts or raw turkey parts contained amounts of lead that were no greater than amounts found in hand-deboned poultry. Use of these kinds of MDP, even at 100 percent usage levels, should not result in a measurable increase in lead consumption.

As a further check on projected lead intakes by infants as affected by use of MDP, data from new consumption studies were utilized. Calculations were made, as previously described in the section on cadmium, on consumption of poultry containing foods by 663 infants in 1972, 1974, and 1977 (F-5). Of these infants, 376 consumed at least one chicken product during the 4-day recording period. Based on these data for consumption

of chicken, median (50th percentile) and 90th percentile intakes of lead from chicken were calculated as described in Table 15. Only data for MDP from fowl and hand-deboned cooked fowl meat from USDA analyses were used in the calculations.

Projected lead intakes given in Table 15 range from 0.04 mcg per day for hand-deboned poultry of average lead content in 1977 to 1.62 mcg per day for MDP of 90th percentile lead content in 1974. To estimate the maximum increase in lead consumption, comparisons were made of values for MDP (fowl) of 90th percentile lead content with hand-deboned fowl of average lead content for the same year and intake class. These comparisons indicate that the maximum expected increase would be 1.4 mcg of lead, or 1.4 percent of the acceptable daily intake of lead for infants. Increases in lead consumption based on average intakes would be much lower, about 0.2 to 0.3 mcg per day. It should be noted that none of these estimates for lead intakes by infants were adjusted for frequency of consumption, and have therefore been overestimated. There is no likelihood that any infants are at risk because of lead content of MDP.

Lead content of diets of 6-month-old children was estimated to be from 116 to 119 mcg per day, or more than the acceptable daily intake of 100 mcg (F-6). Meats, fish, and poultry comprised 4.7 percent of the diet, and contributed 8 mcg of lead per day to the total dietary intake. Complete elimination of all lead from meats, poultry, and fish would not result in bringing infants' lead consumption below the tolerable intake. Decreased lead in infants' diets would be better effected by decreasing

lead in dairy products, which were estimated to provide nearly 60 percent of the dietary lead (F-6).

Although further addition to the lead content of infants' diets is not advisable, the data reported here indicate that replacement of hand-deboned poultry by MDP would not significantly affect the lead content of infants' diets. There is no demonstrated reason, relative to lead content, to limit use of MDP in baby foods or in other meat or poultry products.

G. Selenium

A recommended daily intake of selenium that ranges from 0.05 to 0.2 mg for adults may be included in the next revision of the Recommended Dietary Allowances, due to be published in 1979 (G-1). Selenium is toxic to some animals at intakes of 10 to 100 times those normally ingested (G-2). Data from FDA's Fiscal Year 1975 survey on metals in foods (G-3) indicate a mean dietary content of 185 mcg selenium; this intake would represent that of a 15- to 20- year old male, whose food consumption is probably somewhat higher than that of other adults. Chicken provided about 10 percent of the total dietary selenium. Chicken ranged in selenium content from non-detectable amounts to 0.73 mcg selenium per gram, with an average for 71 samples of 0.306 mcg per gram.

Available data on selenium content of various kinds of MDP, MP(S)P, and hand-deboned poultry are given in Table 16. Although three different methods of analysis--atomic absorption spectrophotometry, neutron activation, and fluorometry--had been used in making the determinations, the data show little difference among kinds of MDP, between MDP and hand-deboned poultry, and between MDP and MP(S)P. Average contents of selenium in products listed in Table 16 were about half the average reported by FDA (G-3), and all values for MDP fell well within the range reported by FDA. It can therefore be concluded that MDP, like hand-deboned poultry, contains nutritionally important amounts of selenium that do not approach toxic levels.

Comparisons of data for selenium in MDP and in hand-deboned poultry, as noted, show that the two types of product contained similar amounts

of selenium. Therefore, substitution of MDP for hand-deboned poultry would not be expected to affect selenium content of the diet for any age group, and MDP can be judged to pose no health hazards in terms of its selenium content.

H. Strontium-90

Although at the present time the levels of strontium-90 contained in food because of nuclear fallout are low, there is still considerable concern about the presence of strontium-90 in food, water, air, and the human body. All isotopes, radioactive or not, of strontium are concentrated in the mineral skeleton (H-1). Biological removal of radiostrontium (strontium-90) from bone, once it has been deposited, is relatively slow, depending mainly upon the extent of bone resorption and mineral exchange (H-2).

Some ingested strontium is deposited in bone in a manner similar to calcium. However, there are metabolic mechanisms which distinguish between the two elements. Data on humans and laboratory animals indicate a preferential deposition of calcium over strontium so that the strontium:calcium ratio in bone is about one-fourth of the ratio in the diet for persons 1 year of age and older. The corresponding ratio for infants under 6 months is 1.0 (H-2). These ratios differ little with differing dietary habits. It is both meaningful and convenient to use strontium:calcium ratios in evaluating the deposition of radioactive strontium.

Data on strontium-90 content of MDP from cooked fowl frames and of corresponding hand-deboned cooked fowl were used in evaluating the potential health hazards from use of MDP. MDP from fowl was analyzed because the levels of strontium-90, if present, would be the highest in older birds. In addition, however, data were obtained from unpublished sources on strontium-90 in raw chicken parts and raw turkey parts for comparison with the data on cooked fowl frames.

MDP prepared from cooked fowl frames contained, on the average, approximately 75 pCi/kg less strontium-90 than the amount found in MP(S)P prepared from beef, and about 2 pCi/kg more strontium-90 than found in hand-deboned cooked fowl (Table 17). The ratio in MDP was 1.8 pCi strontium-90 per gram of calcium.

Unpublished data from Michigan State University (MSU) (H-3) showed 22.4 pCi of strontium-90 per gram of calcium in commercially prepared MDP made from young chicken parts. The difference between USDA and MSU results may be more apparent than real. One of the MSU workers (H-4) has stated that the amount of strontium-90 found was near the limits of detectability for the analytical system employed, and that it could not be said with certainty that these amounts were significantly greater than the background count. Although information on counting error was not available for the MSU analyses of strontium-90 in MDP, analyses made in the same research on bones of rats fed the MDP showed a standard error of the mean which was twice the value for the mean. This finding indicates a lack of certainty that frequently accompanies analyses made near the detection limits of a system, and supports the investigator's conclusion that strontium-90 values were essentially no different from background.

Data provided by the Special Poultry Research Committee (H-5) on strontium-90 in mechanically deboned turkey also showed higher values than those found by USDA for MDP from cooked fowl frames (Table 17). The values for turkey were likewise reported as being difficult to distinguish from background counts.

Exposure to strontium-90 from use of MP(S)P was previously estimated, using market basket data for 1976 as a basis for current exposure of the population, and was found to be insignificant (H-6). To estimate potential maximum exposure to strontium-90 from MDP, the following assumptions were made:

(1) MDP was assumed to consist of 64 percent chicken and 36 percent turkey, the proportions found for "further processed" poultry produced in 1976 (H-7).

(2) Mechanically deboned chicken and turkey were assumed to contain 2.5 pCi and 12.2 pCi of strontium-90 per kilogram respectively.

(3) MDP was assumed to be consumed in the same proportions and amounts, and with the same frequency, as was estimated (H-6) for products projected to contain MP(S)P.

Based on these assumptions, a weighted average value for strontium-90 in MDP was calculated to be 6.0 pCi per kilogram. Consumption data calculated with this weighted average showed that increased exposure to strontium-90 would be insignificant, even if MDP were used in products at a level of 100 percent of the poultry ingredients (Table 18). The highest consumption value calculated was 0.08 pCi per day, for the age group 13 to 17 years (Table 18, last column). This intake is less than projected intakes of strontium-90 from MP(S)P for any age group except infants of ages 0-2 years, even though the MP(S)P was assumed to make up only 20 percent of the meat and meat byproducts, whereas MDP was assumed to comprise all (100 percent) of the poultry and poultry products ingredients. Therefore, since the exposure to

strontium-90 from MP(S)P was judged to be insignificant, and using the same basic assumptions, any exposure resulting from use of MDP is also insignificant.

In 1964, the Department sought the advice of the National Academy of Sciences (NAS) about the health significance of the radionuclide content of poultry meat derived from mechanical deboning. The Food Protection Committee of NAS at that time concluded "the amount of bone remaining in poultry meat has no significance as a health factor in regard to strontium-90 as long as the strontium-90 to calcium ratio of the product does not exceed that prevailing in cow's milk" (H-8). The strontium-90:calcium ratio for milk that was cited by the NAS report was 32.6 pCi per gram of calcium, which was found in milk from New York City during November 1963. Comparable ratios in milk for later time frames are given in Table 17, and show a considerable decrease with time because atmospheric nuclear tests have been reduced. The ratios in milk were 3.1 and 3.3 pCi per gram of calcium in July of 1977 and 1978 respectively (H-9, H-10). These values are nearly twice as high as the ratio currently found in MDP from cooked fowl frames of 1.8 pCi of strontium-90 per gram of calcium.

If we assume the values from young chickens to be different from background even though, as noted earlier, the investigation reported the values to be as close to background as could be measured (H-5), then the 22.4 pCi of strontium-90 per gram calcium is still lower than the value cited by NAS in its 1964 report, and does not exceed the National average for milk in July 1964 (H-11).

A semipurified control diet, or diets containing the mechanically deboned chicken (with an apparent 22.4 pCi strontium-90 per gram of calcium) or hand-deboned chicken, were fed to weanling rats (H-13). After 28 days on the diets, the young rats were killed, and their right femur bones were analyzed for strontium-90. Results, given in pCi per gram of ash, showed averages of 2.4 for bones of rats fed hand-deboned chicken; 0.25 for those fed MDP; and 3.8 for bones from rats on the control diet. Variance was large for all groups of animals, as indicated by standard errors of the mean that were larger than the mean values, and the results showed no significant differences. Since, as was discussed above, other investigators have found less strontium-90 in MDP than did Skrypec et al., it is likely that other studies on growing animals would likewise show a lack of effect on strontium-90 content of animal bones from feeding of MDP.

It can be concluded that MDP poses no health hazards in terms of its strontium-90 content and there is therefore no reason to restrict use of MDP because of its content of strontium-90. This conclusion is supported by the data showing that the level of strontium-90 in bones of growing rats fed MDP is no greater than the amounts found in bones of rats fed hand-deboned poultry or a control diet, and that strontium-90 is present in smaller amounts in MDP than in MP(S)P and in 1977-1978 market milk.

I. Cobalt

Cobalt is an integral part of vitamin B_{12}; there is no evidence that the element has a function in the normal nutrition of humans in any other form (I-1). The typical daily intake of cobalt by adults has been summarized as averaging approximately 0.4 mg per day, with a range from 0.13 to 1.4 mg per day (I-2).

The toxic effects of high intakes of cobalt, especially when accompanied by heavy drinking of beer, have been reviewed by Underwood (I-3). Daily intakes of 8 mg cobalt sulfate (approximately 3 mg of cobalt) ingested in 5 liters of beer produced severe cardiac failure; the length of time taken to develop the toxic effects was not stated by Underwood. When the complicating factor of heavy alcohol consumption is not present, higher cobalt intakes, approximately 20 to 30 mg of cobalt per day, will produce toxic symptoms.

Data on cobalt content of different types of MDP, obtained by two different methods, are given in Table 19. These values differ little from each other or from cobalt content of hand-deboned poultry. They are somewhat lower than values for cobalt in MP(S)P, as mean values for MDP are similar to minimum values for MP(S)P. This relationship is similar to that for vitamin B_{12} content of beef and chicken, as beef contains approximately four times as much vitamin B_{12} as does chicken (I-4).

Because data for cobalt in MDP are indistinguishable from data for hand-deboned poultry, estimates are not needed and have not been calculated for cobalt intakes associated with use of MDP, in order to

evaluate the product. The close agreement between poultry products deboned by hand and by mechanical means show that MDP poses no hazards relating to its cobalt content.

J. Copper

Copper is an essential element in human diets. A U.S. recommended daily allowance (U.S. RDA) of 2.0 mg for adults and 1.0 mg for children under 4 years has been established by the Food and Drug Administration (J-1) on the basis of typical intakes that appear to be adequate, as published by the Food and Nutrition Board of the NAS/NRC (J-2). However, copper in excessive intakes can be toxic; for example, an outbreak of gastroenteritis, which was reported by a Vermont hospital, was attributed to excessive copper, 7 to 70 mg per liter, in water and ice; it has been recommended that water supplies not exceed 1 mg per liter (J-3).

Because copper can cause problems if intakes are either deficient or excessive, the copper contents of various types of MDP were evaluated and compared with copper contents of other meat or poultry items. Copper content of MDP was found to be in good agreement with copper content of MP(S)P made from pork and of hand-deboned poultry, and only slightly higher than copper in MP(S)P made from beef (Table 20). Considerable variability in copper content of hand-deboned poultry was observed, particularly between the compiled values of Pennington and Calloway (J-4), which were determined primarily by colorimetric and gravimetric methods, and newer data obtained by atomic absorption (J-5, J-6, and the present USDA study).

The Residue Evaluation and Planning Division of FSQS has established that approximately 90 percent of the values for copper in muscle of young chickens and turkeys, and about a third to a half of the copper

values for ducks, geese, and mature chickens, are in the range of 1 mcg per gram or less (J-7). Thus, the values reported here for copper in MDP are within the normal limits found for muscle of poultry.

A recent report by Klauder and Petering (J-8) provides evidence that lead-induced anemia results from the antagonistic effect of lead on copper metabolism. They found that supplementation with copper alone prevented the lead-induced depression of hemoglobin levels in rats. However, increases in lead intakes, even at very high levels of consumption of MDP, are projected to be slight (see section F). There should therefore be no need to increase copper intakes because of lead in MDP.

The copper content of MP(S)P made from beef and pork, it has been found, would provide very small increases in the dietary copper intake of the U.S. population and would not pose any problems of significance to public health (J-9). In view of the close agreement in copper content between MDP and MP(S)P, and between MDP and hand-deboned poultry, it can be concluded that MDP poses no health hazards in terms of its copper content.

K. Iron

Iron is a required nutrient for humans, and is a component of hemoglobin, myoglobin, the cytochromes and other iron metalloproteins (K-1). Recommended dietary allowances (RDA's) for iron have been established (K-2). Iron intakes are frequently inadequate (K-2, K-3), and iron deficiency anemia has been found to be a public health problem in the U.S. (K-4). Bioavailability of the iron in a food as well as the amount of iron present is of concern to nutritionists. Heme iron as it occurs in animal meats is considered to be a reliable source of available iron, and to be less dependent on influences of other dietary components than is the iron found in foods such as eggs or vegetable products (K-2).

Data are given in Table 21 for iron contents of various types of MDP, hand-deboned poultry, and MP(S)P prepared from beef or pork. As the table shows, the iron data are very variable. Values for both cooked fowl frames and the corresponding hand-deboned fowl had a wide range. Data which were taken from non-USDA sources on iron in MDP tended to group around the low end of the range found for the USDA data.

The mean value for iron in hand-deboned cooked fowl was higher than the average iron content of the corresponding MDP. This finding was in contrast to earlier USDA data on iron in MP(S)P made from beef, which was considerably higher in iron content than the corresponding hand-deboned beef (K-5). However, the range of values for the two groups of poultry data overlapped to such an extent that there may be no practical difference between them.

One possible explanation for the lower iron content of MDP compared with hand-deboned poultry might be the diluting effect of fat in the MDP. When expressed per gram of protein, iron contents of MDP and hand-deboned poultry were similar, averaging 267 mcg and 221 mcg respectively. A study of mechanically deboned broilers showed that fat derived from skin diluted the heme pigments, which are iron-containing compounds (K-6).

Data were available for both protein and iron in only three samples of MDP made from broilers; iron content of these samples ranged from 105.8 to 146.1 mcg per gram of protein. Additional data would be helpful to determine whether or not iron content of MDP made from young birds is definitely lower than iron in MDP from cooked fowl frames, as these few values suggest. Research from the University of Nebraska found higher total pigment (heme and myoglobin) levels in MDP made from broilers than levels reported by others for MDP made from spent hens. They postulated that, compared with spent hens, the bone marrow from young birds should contribute more pigment to mechanically deboned products (K-6).

Data on iron bioavailability and iron content of turkey frames (presumably raw) were obtained after Table 21 had been prepared (references K-7 and K-8). These data were based on research conducted at Utah State University, and showed lower iron contents than many values listed in Table 21 -- averages of 20 and 11 mcg per gram were found for MDP and hand-deboned turkey, respectively (data not tabulated), as compared with average values in Table 21 of 42.7 and 16.5 mcg iron per gram of MDP made from raw turkey frames and raw turkey parts, and 15 mcg iron per

gram of hand-deboned turkey. Also, in the Utah research, MDP from turkey was higher in iron than was hand-deboned turkey. In comparison, USDA's analyses found a lower average iron content in MDP from fowl than in hand-deboned cooked fowl frames.

Why USDA values for iron in both mechanically deboned and hand-deboned cooked fowl should be so much greater than most iron values from other sources is not known. Iron analyses made by a spectrophotometric method (see Appendix) by the primary laboratory were confirmed by a second laboratory, using atomic absorption spectrophotometry. Therefore, a problem in analytical methodology is not indicated. Although the unexplained wide range in iron values is a problem in establishing representative values for iron in mature chicken, it does not preclude evaluating MDP for safety of use, in terms of its iron content.

As Table 21 shows, iron in MDP was similar to iron content of MP(S)P, although the poultry product had a wider range of values. Since iron in MP(S)P was not found hazardous (K-1), MDP should also present no health hazard from iron.

Calculations were made to estimate the effects on per capita iron intakes from poultry when hand-deboned poultry is partially replaced by MDP. The per capita calculations were based on 1976 data for consumption of poultry (K-9) and for proportions of poultry production made up of ready-to-cook and further-processed poultry (K-10). Details of the calculations are given in Appendix Table VII-3. These calculations indicate that the per capita daily intake of cooked poultry would provide 0.9 mg (926 mcg) of iron if all poultry were from hand-deboned sources, and

1.0 mg (1007 mcg) of iron if all further-processed poultry were MDP. The difference, 0.1 mg, is negligible, and indicates that use of MDP would result in no measurable change in iron contribution to the diet by poultry.

As a further check on consumption, data were calculated to determine maximum changes in iron consumption that would occur if MDP contained less iron than hand-deboned poultry. USDA data from Table 21 for cooked fowl were used in making the calculations. Products containing MDP were assumed to be present in the diet in the same kinds and amounts as was MP(S)P (K-1). Data are given in Table 22 for projected iron consumption from MDP and hand-deboned poultry at two levels of use in products--20 percent and 100 percent of the total poultry and poultry products ingredients.

Data in Table 22 show that at 90th percentile levels for both consumption of MDP and iron content of MDP, products in which MDP makes up 100 percent of the poultry ingredients would provide a sizable proportion of the daily goal, from 10 to more than 25 percent of the RDA, for persons aged three and over. However, the same amount of hand-deboned poultry would provide even more iron, from almost 15 to more than 35 percent of the RDA for the same age groups. Differences in percentage of the RDA for iron that would be provided by the two products were largest for adult men, who are not usually considered to present problems in meeting the iron RDA. The differences observed for females of child-bearing age, 6.3 and 5.7 percent of the RDA, amount to about 1 mg of iron per day out of the RDA of 18 mg (K-2). The difference between the two products for

infants aged zero to two years, 2.2 percent of the RDA, would amount to 0.3 mg per day out of the daily dietary goal of 15 mg iron for this age group. These differences are for intakes at very high consumption levels; differences in iron contribution of the two types of poultry products at average levels of MDP could be expected to be smaller than differences at 90th percentile levels, because intakes would be lower. These data indicate that, for women of child-bearing age, substitution of MDP for hand-deboned poultry would at worst bring only a small measure of disadvantage in terms of iron intakes. It should be reemphasized that the USDA data used in these calculations did not show the usual pattern of relationship between hand-deboned poultry and MDP, in terms of iron content. It is more likely that effects on iron nutriture would be negligible, as shown by data for per capita consumption.

Mechanically deboned chicken meat has been found to contain 54 percent of the iron in the form of heme iron (K-11). This is in agreement with the range of 50 - 60 percent heme iron assumed to be present in hand-deboned chicken for the purpose of calculating available dietary iron absorption in humans (K-12). The biological availability of iron is dependent on the form in which the iron is present in the food, as well as on other foods consumed at the same meal. Heme iron is more readily absorbed than non-heme iron. In addition, animal tissues enhance the absorption of non-heme iron. Since the distribution between heme and non-heme iron in MDP is approximately the same as in hand-deboned chicken meat, the availability should be the same as well.

The efficiency of converting iron to hemoglobin, using rats as the test animal, was found to be 41 percent for MDP and 39 percent for hand-deboned turkey frames (K-8). Reported values for metabolizable iron per gram of product were 8 mcg for MDP and 4 mcg for hand-deboned turkey. Information on the proportion of heme iron was not given. In contrast to the findings from Table 22 which indicate that use of MDP instead of hand-deboned fowl could possibly be a disadvantage, the Utah research indicates that use of MDP could show some advantage over hand-deboned turkey as a source of iron in the diet. Data are not available to show whether or not the differences in results between USDA and Utah could be due to species or age of bird.

More data on matched samples of MDP and hand-deboned poultry would be helpful in establishing with better accuracy the variability in iron content of the products and in determining more fully the differences in total iron content between MDP and hand-deboned poultry. Further data on bioavailability of iron in MDP and hand-deboned poultry would also help in developing a fuller understanding of the effects on iron nutriture that could result from consumption of MDP.

On the basis of information currently available, it can be concluded that iron from MDP presents no hazard to health and that the use of MDP rather than hand-deboned turkey, chicken, or fowl would have little effect on iron nutriture.

L. Nickel

Evidence of both the essential nature of nickel for some experimental animals (L-1) and its toxicity at high intakes (L-2) has been previously summarized. However, the implications of these findings regarding requirements for adequate nutriture of humans are unknown (L-3).

Contents of nickel found in cooked MDP from mature and young chickens, hand-deboned cooked fowl (mature female chickens), and MP(S)P are given in Table 23. The USDA data in Table 23 show that, on the average, MDP from cooked fowl frames contained about 50 percent more nickel than did the corresponding hand-deboned fowl. The range in values for nickel was much wider for MDP than for hand-deboned product, and included several very high values; the 90th percentile value, 1.31 mcg per g, was only about half the maximum value of 2.84 mcg per g. Values obtained from the poultry industry for nickel in MDP, primarily from cooked fowl frames, were all within the range found in the USDA data, and were in good agreement with the USDA average value. The reason for the occasional high values for nickel in the USDA samples is not known. It was difficult to obtain homogeneous samples in some cases, so that replicate values showed poor agreement; such values have not been used in the present summary. However, for the samples with high values included in the mean, duplicate values were both high.

Data for nickel in MDP and hand-deboned cooked fowl showed average nickel contents that were only slightly higher than average values for MP(S)P (Table 23). Ranges for data from MP(S)P fell completely within the ranges of data for nickel in either MDP or hand-deboned cooked fowl.

The 90th percentile value for nickel in MDP, 1.31 mcg per g, was approximately three times the value found for beef MP(S)P, 0.44 mcg per g, and pork MP(S)P, 0.49 mcg per g (L-4).

Daily intakes of nickel by human adults has been found to range from 0.1 to 0.8 mg per day, with an approximate average of 0.3 mg per day (L-5, L-6, L-7). This is equivalent to approximately 4.27 mcg per kg body weight per day for adults (Table 24). Nickel is relatively nontoxic, and can be compared to iron and zinc in this respect (L-5). Nickel toxicity in humans via the oral route occurs only in extreme and unusual circumstances. Abnormally high levels of dietary nickel are required to overcome the homeostatic mechanisms that control nickel metabolism (L-2). Toxicity studies in animals have shown a wide variability in the amount that can produce toxic symptoms, based in part on the form of the nickel fed. An intake of 5 parts per million (ppm) of nickel as nickel acetate in the drinking water of rats during three generations produced decreased litter size, some runting and increased mortality (L-8). Assuming that the rats consume twice as much water as food, this is equivalent to 10 ppm in the diet (dry weight basis). Levels of 250 ppm of nickel carbonate in the diet were found to produce no adverse effects in rats, monkeys, and cattle (L-9).

Projected maximum intakes of nickel from products containing MDP or MP(S)P were calculated, using data for 90th percentile intakes and 90th percentile nickel contents in the MDP or MP(S)P (Table 24). These data show that only a small proportion of the typical daily intake of nickel would come from MDP made from cooked fowl frames if the MDP were

allowed at a level of 20 percent of the poultry ingredient(s) in products. However, if allowed at a rate of 100 percent of the poultry ingredient(s), MDP might provide as much as 25 percent of the typical daily intake (Table 24). These intakes can be calculated to the basis of parts per million in the diet using factors derived by the Food and Drug Administration (L-9). The maximum intakes are equivalent to 0.062 ppm (mcg per g) in the diet of adult males, and 0.044 ppm in the diet of children ages 4-6. These amounts are less than 0.6 percent of the 10 ppm of nickel in the diet estimated to produce toxic symptoms in rats.

Data from Schroeder and Balassa (L-5) and Tipton et al. (L-6, L-7) formed the basis of the estimated typical daily intake of 300 mcg nickel (Table 24). This estimate was earlier used in evaluating nickel contents of MP(S)P for health and safety (L-10). A more recent estimate of typical daily nickel intakes has been made by Myron et al., who analyzed nine institutional diets, including one normal and eight therapeutic diets (L-11). They found daily intakes of 107 to 221 mcg of nickel, with the normal hospital diet containing 159 mcg nickel per day, and an overall average of 168 $\pm$ 11 mcg. This average amount is about half the earlier estimate. Thus, if Myron's value were used to calculate percentage of total daily nickel intake provided by MDP, the values in Table 24 would be approximately doubled. However, even though MDP might be providing as much as half of the nickel intake, total intakes are so far below amounts which produce toxic symptoms that these newer data would not change conclusions about the safety of use of MDP as related to nickel.

It can be concluded that MDP from cooked fowl frames does not pose any health hazards with regard to nickel. Agreement between nickel values for MDP from cooked fowl frames, hand-deboned cooked fowl, the single value for MDP from raw broiler parts, and MP(S)P prepared from beef or pork was good. This agreement is a good indication that other types of MDP should pose no problems in providing too much nickel.

M. Zinc

As shown in Table 25, data for zinc content of MDP were in good agreement with data for hand-deboned poultry. Following the pattern for poultry muscle, MDP made from turkey appeared to be higher in zinc content than MDP made from chicken or fowl. MDP made from chicken appeared to be similar in zinc content to MP(S)P made from pork, while MDP made from turkey was in good agreement with MP(S)P made from beef in zinc content.

It has been concluded (M-1) that MP(S)P, made from either pork or beef, would not have a significant effect on zinc intake, and that bioavailability of the zinc would not be adversely affected by the high amount of calcium in MP(S)P unless foods high in phytate content were consumed at the same time. Since MDP contains less calcium than does MP(S)P and is comparable to hand-deboned poultry and MP(S)P in zinc content, it can be concluded that the use of MDP does not pose a hazard to health.

Per capita consumption of zinc from poultry with and without MDP was calculated, using the same procedures as for iron (see Appendix Table VII-3 for a description of the calculations). If no MDP were included in the poultry, the daily per capita consumption of zinc would be 0.94 mg. If all of the further processed poultry (15 percent of total poultry) were from MDP, the daily per capita consumption of zinc would be 1.00 mg. The difference, 0.06 mg, represents 0.4 percent of the RDA for adults of 15 mg (M-2) and is negligible.

As shown in Table 26, MDP at current estimates of intake would provide only small amounts of zinc to the diet. Even assuming that MDP were

present as 100 percent of the poultry ingredient(s) in formulated meat products, only 3 to 5 percent of the 1974 RDA for zinc (M-2) would be provided.

Zinc content of diets would appear to be little affected by the presence or absence of MDP.

N. Chlorinated Hydrocarbon Residues

Tolerances or action limits are the upper limits that a food item may contain of a chlorinated hydrocarbon pesticide and still be considered wholesome. These levels are established by or with the advice of the Environmental Protection Agency only after consideration of all available scientific data and of determining whether or not a residue is unavoidable.

Table 27 gives the frequency of occurrence of different levels of five chlorinated hydrocarbon residues--benzene hexachloride (BHC), dieldrin, DDT, heptachlor, and hexachlorobenzene (HCB)--in fat from three forms of MDP and in hand-deboned poultry from cooked fowl. Also included in the table are 1976 monitoring data for levels of the five residues in fat from chicken and turkey (N-1), and data for the highest levels of residues found. Residues found to be present were all well within the tolerance or action levels. Analyses showed no detectable levels of other chlorinated hydrocarbons.

Frequency percentages for cooked fowl frames showed no differences in residue levels between fat from MDP and fat from hand-deboned poultry. In no case did the maximum residue found in MDP from cooked fowl frames exceed the maximum found in hand-deboned cooked fowl. Because the MDP contained more fat than did the hand-deboned poultry (see Table 28), the overall content of residues would be slightly higher in the MDP than in the hand-deboned poultry. However, differences in fat content among different edible meat or poultry products such as muscle, skin, and

gravy were considered in setting the tolerance or action levels, so that a wide margin of safety is provided for high-fat as well as low-fat products.

Frequency percentages for MDP showed patterns of distribution similar to those observed in 1976 monitoring data for fat from hand-deboned chicken and turkey; any differences between the two sets of data could easily be a factor of sample size, as the number of analyses made, especially for chicken and turkey parts, was small.

Comparisons of frequency percentages between MDP made from cooked poultry with MDP made from raw poultry, although based on small numbers of samples, indicate that residue levels may be slightly lower in the cooked product. This tentative finding is not surprising, as other studies (N-2, N-3, N-4) have shown that cooking may lower the total amount of residues present in the fat. However, as previously stated, none of the samples of MDP, either raw or cooked, contained residue levels in the fat that approached the tolerances or action levels for chlorinated hydrocarbons. Therefore, it can be concluded that MDP presents no hazard to health and safety, and needs no consideration in monitoring programs beyond that already given to poultry.

These findings on MDP are similar to results and conclusions previously reported for MP(S)P (N-5).

O. Fat, Cholesterol, and Fatty Acids

The relationship of dietary lipids to degenerative diseases, such as vascular disease, is at present unknown. However, some scientific evidence indicates that the reduction of dietary saturated fat and cholesterol, with replacement by dietary polyunsaturated fat, reduces blood levels of cholesterol and may reduce certain forms of cardiovascular disease (O-1). Munro (O-2) has reviewed human consumption patterns for fat and the experimental evidence relating changes in fat consumption to changes in blood lipid patterns. The National Heart and Lung Institute (O-3) has identified several different types of blood lipid patterns found in clinical medicine, some of which require special diets for their control. For some of these types, the kinds or amounts of fats in the diets may be restricted. Desirable amounts of fat in diets of healthy individuals have not yet been established, but there is a widely held belief that total fat content of diets should be controlled.

One in approximately every 150 to 200 infants born each year has an hereditary condition known as familial type II hypercholesterolemia. This condition can usually be diagnosed at birth by measuring the cord blood cholesterol concentration. For these infants, a restricted cholesterol, high polyunsaturated fat diet is prescribed (O-4). Some health professionals believe that the same kinds of dietary restrictions are desirable for all infants, whether hypercholesterolemia has been diagnosed or not (O-5, O-6, O-7), although there is disagreement as to just how restricted the diet should be. Other health professionals believe that it is unwise

and undesirable to make general dietary changes unless the individual infant has been shown to be at risk (0-8, 0-9, 0-10). Part of this philosophy is based on the fact that human breast milk contains relatively high amounts of cholesterol, and that there may be a need for cholesterol in early life in order to form steroid hormones and bile acids, and to induce enzyme systems responsible for regulating the biosynthesis and catabolism of cholesterol (0-11).

To aid in evaluating the effects on health of use of mechanically deboned poultry, data have been summarized on the content of total lipids and cholesterol, and of fatty acids in lipids. Thus, both the kind and amount of fat in MDP have been examined.

Data on cholesterol in MDP and in hand-deboned poultry are given in Table 28. Cholesterol contents of different kinds of MDP were about double the contents of hand-deboned poultry flesh, and about the same as or slightly higher than cholesterol contents of chicken or turkey skin. The numbers of samples analyzed were too few to conclude with confidence that presence or absence of skin in the MDP had any effect on cholesterol content, but the few data available showed no relationship. For data on samples with and without skin, see Appendix Tables III-2 and III-3.

Although the increased cholesterol content may be due in part to the presence of skin in MDP, it also appears probable that bone marrow in the MDP contributes to the increase. Moerck and Ball (0-12) determined lipid fractions from chicken bone marrow and found the marrow to be 1.3 to 1.4 percent (1300 to 1400 mg per 100 grams) cholesterol, with an additional

0.2 to 0.3 percent cholesterol ester. Little information is available on the amount of marrow in poultry bones. Marrow content varies in amount with age of the bird, and varies between different bones from the same bird. It is difficult to separate marrow from the inner surfaces of hard bones, and to determine what proportion of the separated tissue is marrow (0-13). Therefore, information is not currently available to permit estimates of the proportion of cholesterol in MDP contributed by marrow. However, marrow containing the amount of cholesterol reported by Moerck and Ball, if present in MDP as no more than 5 percent of the total ingredients, could be expected to add 65 to 70 mg of cholesterol per 100 grams of product.

To estimate the effects of MDP on cholesterol intakes, consumption values were estimated in three ways--per capita increases based on production information (0-14, 0-15), increases for different age groups, based on consumption data for individuals from the 1965-1966 Household Food Consumption Survey (0-16), and intakes of cholesterol by infants, calculated from data for consumption of poultry by infants in 1972, 1974, and 1977 (0-17).

Estimated increases in per capita cholesterol intake were calculated, and are shown in Appendix Tables VII-1 and VII-2. Assuming that all further-processed poultry was MDP, that it made up 15 percent of the total poultry in the market, and that the proportions of young chicken, mature chicken, and turkey were those given in Appendix Table V-1, the projected increase in per capita cholesterol intake would be 4.9 mg per day. This

added amount would be equivalent to 2 percent of the cholesterol found in one egg (274 mg) or slightly less than half of the cholesterol found in one 5-gram pat of butter (11 mg) (0-18). Because all of the further-processed poultry was assumed to be MDP, this projected per capita increase is overestimated. It can be concluded that the increase in cholesterol consumption would be negligible.

The second approach to estimating increases in consumption was made using consumption estimates for MP(S)P, as previously described (0-19). Data for increases in consumption of cholesterol if MDP or MP(S)P were used as 20 percent, and MDP as 100 percent, of the total meat, meat byproduct, poultry, or poultry product content of meat products are given in Table 29. These data are for 90th percentile intakes of products with 90th percentile cholesterol contents for MDP and MP(S)P, and average cholesterol contents for the hand-deboned products. The estimates assume that all MDP was from cooked fowl frames.

According to these data, projected increases in cholesterol consumption would range from 9.5 to 33 mg per day, assuming MDP were used as 100 percent of all meat or poultry ingredients in products. The highest increase, 33 mg, represents about 12 percent of the cholesterol found in an average egg. These estimated increases are probably considerably overstated, as it is highly unlikely that even the few people eating at the 90th percentile level of intake would eat only formulated products containing MDP, or that all of those products would contain MDP as 100 percent of the meat or poultry ingredients and that the MDP would

contain cholesterol at the 90th percentile level. Table 29 also shows that increases in cholesterol consumption would be about the same for MDP and MP(S)P, if used in products at the same percentage of the total meat, poultry or byproducts ingredients.

To evaluate the impact of the increased cholesterol content of MDP on infants' diets, consumption data from the National Food Processors Association (0-17) were used to calculate cholesterol consumed from MDP. Calculations were made in the same manner as was done for fluoride.

Table 30 gives data on 50th and 90th percentile intakes of poultry products by infants from data collected in 1972, 1974, and 1977. In calculating the potential increase in cholesterol when MDP is substituted for hand-deboned poultry, weighted values for average cholesterol in hand-deboned poultry and maximum cholesterol content of MDP were used. The increases would range from 2.3 mg per day at the 50th percentile intake for 1977 to 15.6 mg per day at the 90th percentile intake for 1974. Some researchers recommend that all infants consume less than 200 mg cholesterol per day (0-5, 0-20), while others recommend less than 300 mg cholesterol per day for those infants which have been diagnosed to have familial type II hypercholesterolemia (0-4). The maximum increased level (Table 30) of 15.6 mg per day at the 90th percentile intake level represents 5 and 8 percent of the suggested 300 or 200 mg per day respectively.

It is important that people who are carefully watching their cholesterol intakes, especially those with familial type II hypercholesterolemia who begin cholesterol restriction early in life and continue throughout the lifespan, be able to identify which products contain MDP. Poultry is frequently

recommended as a replacement for some meat in low-fat, low-cholesterol diets, and the average cholesterol content of MDP is higher than that found in hand-deboned poultry. Therefore, foods containing MDP should be specifically labeled to show its presence. Labeling to designate presence of MDP is preferable to labeling for cholesterol content unless all foods are to be labeled for cholesterol. If this recommendation becomes final, then an extensive information distribution program will be needed to alert health professionals to the dietary implications of this product in relation to cholesterol-restricted diets.

For the general public, the cholesterol values for MDP are comparable to those found in shrimp and sardines (140-150 mg per 100 g) and are considerably lower than the cholesterol content of eggs (0-21). The cholesterol level is not high enough to be of concern for normal individuals.

Table 31 gives data on the major fatty acids in the lipid portion of MDP and hand-deboned poultry. Data were calculated using a computer program developed for food composition tables that allows for normalization of the data (0-22).

Fatty acids found in largest amounts in both MDP and hand-deboned poultry were palmitic (C 16:0, a saturated fatty acid); oleic (C 18:1, a monounsaturated fatty acid), and the essential fatty acid linoleic acid (C 18:2, a polyunsaturated fatty acid). For cooked fowl, no differences were found in palmitic acid or linoleic acid contents between MDP

and hand-deboned poultry, but oleic acid was significantly higher in the MDP. Fatty acid data obtained from other sources also showed this same pattern--general agreement on contents of palmitic and linoleic acids, but slightly more oleic acid in the MDP (Table 31). Munro (0-2) states that there is no general agreement regarding quantitation of the effects of various combinations of fatty acids in diets on serum cholesterol levels, but that intake of polyunsaturated fatty acids should be high if serum cholesterol is to be reduced. Substitution of MDP for hand-deboned poultry in processed products would not affect linoleic acid content of the final product, and might increase slightly the content of oleic acid. These findings indicate that quality of the fat in MDP, in terms of its fatty acid profile, poses no health hazards.

Data on fatty acids in lipids from chicken bone marrow are given in Table 31. A comparison with data for hand-deboned chicken indicates that the marrow was similar in fatty acid content to hand-deboned poultry skin. Therefore, no alteration in fatty acid content of MDP because of the presence of marrow lipids would be expected.

Table 32 summarizes the data on content of total lipids in MDP and hand-deboned poultry. These data showed a wide range of fat content in both types of products, although there was a tendency for MDP to be higher in fat content than was hand-deboned poultry.

As the skin is one of the major sources of fat in poultry, it is not surprising that both hand-deboned poultry and MDP containing skin were considerably higher in fat than were products not containing skin.

Marrow, too, has a high fat content. Moerck and Ball (0-12) reported an average lipid content of 46.5 percent for bone marrow from 8 to 9 week-old broilers. Bone marrow thus contains about the same percentage of fat as skin, and could be expected to contribute to the total lipid content of MDP, even though present in minor amounts. The anatomical part of the animal used also affected the fat content of MDP; product containing backs tended to be higher in fat than product not containing backs (data not tabulated).

Although proposed standards for poultry sausages have been published and included fat limitations (0-23), there are currently no regulations in force that would limit fat content of poultry products containing MDP. Therefore, in view of the desirability of avoiding further increases in the total fat content of American diets, it is recommended that fat content of MDP should be restricted within the limits of good manufacturing practice.

P. Protein Content and Quality

Proposed parameters for the quality of protein in MP(S)P were reviewed by the Select Panel on Health and Safety Aspects of the Use of Mechanically Deboned Meat and found to be acceptable (P-1). These proposed standards were a Protein Efficiency Ratio (PER) of no less than 2.5, or, as an alternate measure of quality, an amount of essential amino acids (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) totaling no less than 33 percent of total amino acids (P-2). The Panel recommended that the amino acid alternative to PER be accepted only for a limited time, during which reliable and less expensive alternates to the PER should be sought. Proposed requirements for minimum protein content were not reviewed by the Panel.

To establish parameters for protein and protein quality suitable for use with MDP, data were gathered and evaluated on amino acid contents, PER, and total protein contents of MDP.

Table 33 reports data on the content of eight amino acids considered to be essential to humans, plus two amino acids--cystine and tyrosine--which have a sparing action on the amounts of methionine and phenylalanine required by the body. (Histidine, which is generally recognized as essential for infants (P-3), is listed in Table 34.) Data were calculated on the basis of the content per gram of nitrogen, and are given for several forms of raw and cooked MDP, hand-deboned poultry, and two standard proteins used as a benchmark for measuring protein quality. Comparisons of MDP and hand-deboned poultry prepared from the same cooked fowl showed no differences in content of any of the amino acids. Data taken from

the scientific literature also showed few differences between amino acids in MDP and standard values for amino acid content of poultry muscle. The few differences noted in the table could as well be attributed to problems of analytical methodology and sample preparation as to differences in amino acid contents of products.

Casein, the protein used as the standard in determinations of PER, appeared to be higher in isoleucine, leucine, the aromatic amino acids, and valine than were proteins from either hand-deboned or mechanically deboned poultry. However, compared with the standard pattern proposed by Williams et al. (P-3), for use in scoring proteins, the essential amino acid profile for MDP appeared completely adequate. Williams' proposed pattern was derived to meet the needs of infants for amino acids, and to more than meet the needs of adults, provided the total nitrogen requirements were met. Therefore, proteins from MDP and hand-deboned poultry, which equaled or exceeded the standard pattern, could be expected to provide enough essential amino acids to meet the needs of children and adults.

Data for nonessential amino acids are summarized in Table 34. These data show very similar contents for MDP and hand-deboned poultry prepared from cooked fowl, with the exception of hydroxyproline, glycine, and possibly proline. These three amino acids appeared to be higher in MDP than in hand-deboned poultry. Since hydroxyproline is present primarily in collagen proteins, the higher hydroxyproline contents indicate that MDP can contain more connective tissue than does poultry muscle.

Collagen content of protein, determined from hydroxyproline data, has been reported to be 4.0 and 5.0 percent for raw and cooked hand-deboned chicken respectively, and 7.9 percent for mechanically deboned raw chicken (P-4). In contrast, protein from mechanically deboned cooked chicken had a collagen content of 25.2 percent. The authors explain this high collagen content as coming from chicken skin, which was gelatinized during cooking and extruded with the meat during mechanical deboning, rather than being discarded with the waste fraction. The pattern found by these authors (P-4) of higher collagen in MDP from cooked poultry than from hand-deboned poultry or uncooked MDP parallels the pattern of hydroxyproline values shown in Table 34.

Although hydroxyproline was found in greater amounts in MDP than in hand-deboned fowl meat (Table 34), no relationship could be noted between hydroxyproline content and PER. Data for the two measurements, when graphed (Figure 1), showed a random scatter, with both low and high PER's found in samples low in hydroxyproline, and low and high PER's found in samples high in hydroxyproline.

Data on protein quality, as measured by direct determination of PER, PER calculated from equations, and essential amino acids calculated as percent of total protein or of total amino acids, are given in Table 35. Equations used in calculating PER's were those developed by Alsmeyer et al. (P-5), using beef tissues.

PER values were higher in MDP from cooked fowl frames than in standard casein, but were lower for the MDP than for hand-deboned fowl

meat from the same source. Of the 26 samples of MDP from cooked fowl frames, five had PER values lower than 2.5. However, a PER of 2.03 was the only value which fell more than one standard deviation below 2.5, the standard value for casein. All but one of the low PER's were in product from a single establishment.

Values for PER's for other kinds of MDP were almost entirely greater than the standard PER for casein. In general, PER's tended to be higher for MDP made from raw poultry than for MDP made from cooked poultry. Literature data, however, are difficult to interpret, as reports do not always indicate whether or not data had been corrected to a reference point of 2.5 for casein. For raw and cooked chicken racks, data taken from the literature (P-6) were from assays in which a 5:1 mixture of casein and lactalbumin, rather than casein alone, was used as the standard. Because lactalbumin is considered to have a higher PER than casein, PER's for MDP, when calculated against the mixture, would appear to be lower than if they had been calculated against a casein standard.

One study (P-7) reported PER values showing MDP from raw turkey frames to have a higher PER than either hand-deboned turkey meat or casein: unadjusted PER values were 3.28, 2.98, and 3.15, respectively for the three kinds of protein. These findings are in apparent contrast to the USDA data on cooked fowl frames, and serve to illustrate the difficulty in interpreting data currently available on PER's in poultry tissues. In addition, the numbers of values for PER in the different kinds of MDP were extremely limited, as shown by the number of samples listed in Table 35. Therefore, although it appears that MDP can nearly

always meet the minimum PER of 2.5, there are inadequate data of unequivocal standing to be assured of such protein quality. It might, therefore, be advisable to set a minimum standard for PER in MDP. Such a requirement should be easy for most MDP to meet, and should require a minimum of monitoring for quality control.

Although average values in Table 35 indicate that equation 1, and possibly equation 2, show promise as alternates to bioassays for determining PER's, a further examination of the data indicates that the equations would poorly predict actual PER in individual cases. In Figure 2, bioassay values for PER's have been plotted against values obtained by calculation with equations. For any individual sample, if the two PER values were in good agreement, the point would be located close to the 45 degree line shown in the chart. For both equation 1 and equation 2, the points show considerable scatter in relation to that line. Furthermore, if the chart is divided into quadrants bounded by the lines for a PER of 2.5, the suggested minimum PER for MDP, it can be observed that equation data would give wrong information as to whether or not the actual PER would meet that minimum standard. The upper left hand quadrant shows PER's that were below 2.5 by bioassay, but were predicted by equation to exceed 2.5. Four values for equation 1 and five for equation 2 fall in that quadrant. The lower right hand quadrant shows those PER's which were above 2.5 by bioassay, but were predicted by equation to be less than 2.5. In this quadrant are located seven values for equation 1 and three for equation 2. Thus, inaccurate data for predicting compliance with the minimum PER of 2.5 were obtained in 42 and

31 percent of the 26 samples when equations 1 and 2 respectively were used to predict bioassay values.

Equation 3, according to the data in Table 35, has little value in estimating PER of poultry products. The equations developed for beef are therefore not satisfactory for use with MDP. Additional data and further study will be required if equations are to be developed for predicting the PER of MDP.

Use of percentage of essential amino acids (EAA) as an indicator of PER shows little promise, as judged by the data for MDP from cooked fowl frames. All of the samples with PER's of less than 2.5, as obtained by rat bioassay, had EAA's of 34.5 to 36.9 percent. Conversely, two samples with PER's as high as 2.64 and 3.23 had EAA's of less than 33 percent. The scatter of the data, when graphed (Figure 3), did not show any natural grouping that would indicate a reasonable minimum standard for percentage of essential amino acids.

Total protein contents of MDP and hand-deboned poultry are summarized in Table 36. Protein content was generally higher in MDP prepared from frames or whole carcasses than from parts; from parts without skin than from parts with skin; and from turkey than from chicken. MDP was found to be lower in protein content than hand-deboned poultry in all comparisons. Thus, if MDP were used to replace hand-deboned poultry in the diet, the total amount of protein consumed might be decreased. Consumption data on foods as currently eaten are not available at this time to determine whether MDP replaces or supplements hand-deboned poultry, and whether it increases, decreases, or does not affect intakes of protein.

Recent research (P-8) has shown that food available per capita per day exceeds the goals for both total protein and total essential amino acids by a substantial amount. Nationwide surveys of nutritional status (P-9) and food consumption (P-10) also show that nearly all Americans have protein intakes greatly exceeding requirements. Therefore, even if protein intakes were slightly decreased by use of MDP, no health hazard would be posed.

Moisture-protein ratios were calculated for the 1977 USDA samples whose protein contents are summarized in Table 36. Average values and ranges for these ratios were as follows:

	Avg.	Range
Cooked fowl meat, hand-deboned	2.3	2.1-2.6
MDP, cooked fowl frames	4.1	3.4-5.0
MDP, raw chicken parts	5.1	3.7-6.0
MDP, raw turkey parts	4.6	2.8-6.3

These ratios indicate a considerable dilution of poultry product, possible by ice. Although this dilution does not present a problem of health or safety, it does raise questions as to whether or not MDP meets consumer expectations of what poultry products should be. Consideration should be given to establishing limits for moisture-protein ratios in MDP.

Q. Purines

Purines are compounds which are metabolized to uric acid. The individual purines of metabolic importance are xanthine, hypoxanthine, guanine and adenine. High purine intakes increase the blood and urine uric acid levels and may exacerbate gout in sensitive individuals who either have a reduced ability to excrete uric acid or who have an increased endogenous production of uric acid (Q-1).

Research at the University of California, Davis, on the metabolism of individual purines has shown that guanine had no effect on uric acid levels; xanthine affected urinary uric acid levels, but not blood levels; adenine had a pronounced effect on blood uric acid levels; and hypoxanthine had a lesser effect on blood levels than did adenine (Q-1).

To determine whether MDP has a different purine content from hand-deboned poultry, commercially prepared MDP and hand-deboned poultry samples were analyzed at the University of California, Davis, for USDA (Q-2) and for the Special Poultry Research Committee (Q-3). All of these data, which are summarized in Table 37, were used in evaluating effects of purines in MDP on health and safety.

The total purine content of MDP was essentially the same as that of hand-deboned poultry, and closely approximated the values published by Mattice in 1950 (Q-4). However, the proportion of individual purines appears different between the MDP and hand-deboned samples. Since xanthine and guanine were shown not to affect blood uric acid levels, any increased contents of these two substances in MDP would not present a health hazard. Hypoxanthine was lower in MDP than in hand-deboned

poultry, and hence would not provide an increased risk to hyperuricemic and gouty individuals. Average values for adenine content differed little between MDP and hand-deboned poultry.

Each sample was analyzed in triplicate. For six of the samples, analyses were repeated after 2 months storage in the frozen state. Standard deviations for analytical variation are given in Table 37 for MDP and hand-deboned poultry. For values representing two or more samples of MDP or hand-deboned poultry, standard deviations which take into account differences among samples are also given in Table 37. The mean value for adenine in MDP (all kinds) was within one standard deviation (analytical variation for hand-deboned poultry) of the mean for hand-deboned poultry. For samples listed in Table 37, differences for adenine between MDP and hand-deboned poultry were thus not true differences.

Contents of adenine and hypoxanthine were not affected by frozen storage. For adenine, averages for six samples were 15.89 and 14.84 mg per hundred grams respectively before and after frozen storage. Comparable data for hypoxanthine were 31.54 and 29.55 mg per 100 g respectively for unstored and stored products. These differences, likewise, are within one standard deviation of the analytical variation. Although the number of samples analyzed is small, there is no evidence that adenine in MDP exceeds adenine in hand-deboned poultry and it does not appear likely that additional analyses would upset this finding.

The adenine contents of both MDP and hand-deboned poultry are well below the amount present in foods which are restricted for purine-sensitive individuals. Reported examples of high-adenine foods are (mg

adenine per 100 g raw food): lentils, 104; beef liver, 62; pork liver, 59; and split peas, 88 (Q-5). Even allowing for dilution by water or losses with cooking, these foods would still contain two or more times as much adenine as poultry.

Therefore, since the adenine and total purine contents of MDP do not differ from hand-deboned poultry, poultry is not a high-adenine food, and MDP is lower in hypoxanthine than hand-deboned poultry, MDP does not pose any increased health hazard in regard to its purine content.

R. Microbiology

The microbiology of mechanically deboned poultry (MDP) is dependent upon several factors: the microbiological content of the original raw poultry; handling of the poultry during removal of the primal portions (drumsticks, breast, etc.); time and conditions of holding the material before mechanical deboning; the material to be deboned--frames with little skin versus necks and backs with high skin (surface) levels; and the mechanical deboning process itself. Poultry processing in the U.S. is highly standardized and results in poultry with generally uniform microbiological quality.

During the time period January 1974 to September 1978, the Division of Microbiology of FSQS conducted a microbiological study that compared MDP starting materials with finished MDP. Samples were collected from 17 plants located throughout the U.S. and included frames or necks and backs from chicken and turkey. A total of 228 production line units of starting material (coarsely-ground bones with adhering meat or meat and skin) and 298 units of MDP were collected. Ten units of coarsely-ground starting material and of MDP were usually collected in one establishment at one time. Units were collected at 30 minute intervals during production, frozen promptly, and shipped under dry ice to the laboratory for analysis.

Coliforms, Escherichea coli and Staphylococcus aureus were determined by standard microbiological procedures (R-1). Aerobic plate counts were made after incubation at two temperatures--35°C and 20°C (R-1).

All samples were examined for the presence or absence of salmonellae, using standard procedures (R-1). Since the numbers of salmonellae present in fresh poultry are extremely low, quantification is difficult and, following usual practices, was not performed.

Table 38 compares the frequency distribution of indicator organisms (coliforms, E. coli, and S. aureus) in the coarsely-ground starting material and the finished product (MDP). None of these microorganisms was found in MDP at levels that were excessive for a comminuted raw meat or poultry product. The presence of such organisms at these levels can be expected in raw poultry, and does not indicate insanitary practices (R-2, R-3).

Aerobic plate counts, determined after incubation at 35°C and 20°C, are given in Table 39. Incubation at different temperatures often gives clues concerning handling practices. In this case, the similarity of results for 35°C and 20°C incubation temperatures indicate to a microbiologist that the product had not been held in coolers for extended periods of time. The counts recorded are in general agreement with those reported by Maxcy, et al. (R-4), but are lower than those found by other investigators for retail level ground poultry samples (R-5, R-6). In those cases in which the product bacterial load tended to be higher, it can be attributed to the starting material. In view of this relationship, any deliberation on the need for regulatory controls should include consideration of practices specific to the storage and handling of starting material.

Table 40 shows that 142 of 298 sample units (47.6 percent) of MDP were positive for salmonellae. This 25 percent increase over the

coarsely-ground starting material does not represent an increase in salmonellae, but rather a reduction in sampling error. The process of mechanical deboning results in a homogeneous product with an even distribution of salmonellae, thus increasing the chances of recovery by sampling. Currently, an incidence of salmonellae in raw poultry exists (as is true in red meat, also), and mechanically deboned poultry is not unique in that respect. FSQS policy specifies cooking requirements for ready-to-eat poultry products that result in the destruction of any salmonellae that may have been present (R-7). This regulation regarding the heat treatment of poultry products should be clearly understood to apply to products formulated with MDP.

In summary, samples of MDP in this survey were generally acceptable from a microbiological standpoint. Considerations for regulatory needs should center on (1) an assurance that current policy regarding the heat treatment for ready-to-eat poultry products includes products formulated with MDP, and (2) a consideration of the need for mandating sanitary handling practices specific to material destined to become MDP.

Table 1. Arsenic Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, Poultry Muscle, and Liver

Product	Samples	Average	Low	High	Tolerance Level 1/
	no.	mcg/g	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:					
Cooked fowl frames 2/	26	$<$ 0.02	$<$0.02	$<$ 0.02	
Cooked fowl frames 3/	5	$<$ .02	$<$ .02	$<$ .02	
Raw chicken parts 2/	32	4/ .04	$<$ .01	.12	
Raw chicken parts 3/	1	$<$ .02	--	--	
Raw turkey parts 2/	26	4/ .02	$<$ .01	.06	
Hand-deboned cooked fowl meat	25	$<$ .02	$<$.02	$<$ .02	
Meat (poultry muscle)					0.5
Liver					2.0

1/ Tolerance level is the upper limit that a food may contain of arsenic and still be considered wholesome (A-13).

2/ Data from USDA study.

3/ Source of data: reference A-14. Analysis by atomic absorption spectrophotometry.

4/ In determining the average, 0.005 mcg/g was estimated as the arsenic content for samples having non-detectable amounts.

Table 2. Bone Particle Length in Mechanically Deboned Poultry, Hand-Deboned Poultry, Mechanically Processed Beef Product, and Beef Bone Meal

Product	Type of Mechanical Deboning Equipment	Samples	Maximum Bone Particle Length	Particles with Lengths Equal to or Greater Than 500 Microns or	850 Microns
		no.	Microns	%	%
Mechanically deboned poultry:					
Fowl frames, cooked 1/	Brand A	8	500	100	100
Chicken necks, 20% skin, raw 1/	Brand B	4	350	100	100
Turkey, raw 2/	Brand A	2	1,571	78	94
Hand-deboned turkey meat, raw 2/	--	2	2,856	33	56
Sawed turkey meat, raw 2/	--	2	1,000	53	87
Mechanically processed beef product, raw 1/	Brand A	4	650	99	100
Beef bone meal 1/	--	1	150	100	100
Beef bone meal 2/	--	2	286	100	100

1/ Data from USDA study. Three replicates were analyzed for each sample.
2/ Source of data: reference B-3.

Table 3. Effect of Extraction Procedure on Distribution of Lengths of Bone Particles in Mechanically Deboned Poultry

Kind of MDP	Type of Extraction	Statistical Measure	Bone Particle Length in Microns: Less Than 213	213-300	301-500	501-850	More Than 850	All Sizes
			%	%	%	%	%	%
Turkey, raw: (6 samples) 1/	Alcoholic KOH	Average	84.8	8.6	3.9	2.6	0.1	100.0
		Low	69.3	5.0	1.7	.7	.0	-
		High	91.7	17.0	7.3	5.7	2/ .7	-
Turkey, raw (6 samples) 1/	Papain	Average	74.0	12.0	8.2	5.4	3/ .3	99.9
		Low	70.0	8.0	6.7	3.3	0.0	
		High	81.0	13.7	10.7	7.0	4/ 1.0	
Chicken, raw (1 sample)	Alcoholic KOH	-	87.3	7.0	2.7	3.0	.0	100.0
Chicken, raw (1 sample)	Papain	-	78.3	10.3	5.7	5.0	.7	100.0

1/ Lengths of bone particles were measured for each of three replicates from each one-mg sample, using a calibrated microscope.
2/ Two bone particles measured 1040 and 1100 microns respectively.
3/ Four samples contained bone particles which were agglomerates of hard bone and connective tissue and were easily dispersed.
4/ Sample contained two agglomerates and one particle measuring 960 microns.

Table 4. Cadmium Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, Raw Chicken Kidneys, and Mechanically Processed (Species) Product

Product	Samples	Average	Low	High	Values Below 0.01 mcg/g	
	no.	mcg/g	mcg/g	mcg/g	no.	%
Mechanically deboned poultry:						
Cooked fowl frames 1/	26	< 0.01	< 0.01	0.02	5/ 12	46
Cooked fowl frames 2/	5	.02	.01	.02	0	0
Raw broiler frames 2/	2	< .01	< .01	< .01	2	100
Cooked broiler frames 2/	2	< .01	< .01	< .01	2	100
Raw chicken parts 1/	31	< .01	< .01	.02	30	97
Raw chicken parts 2/	3	< .01	< .01	.02	1	33
Raw fowl 2/	3	.008	.007	.010	2	67
Raw rooster 2/	3	.013	.010	.018	0	0
Raw turkey frames 2/	2	< .01	< .01	.01	1	50
Raw turkey parts 1/	26	< .01	< .01	.02	24	92
Raw broiler backs with kidneys 3/		.004	--	.009	--	--
Raw fowl backs with kidneys 3/		.096	--	.244	--	--
Hand-deboned cooked fowl meat 1/	25	< .01	< .01	.01	6/ 18	72
Raw chicken kidneys: 1/						
Broilers	100	7/ .05	.02	.18	0	0
Fowl	100	7/ .80	.16	2.78	0	0
Mechanically processed (species) product: 6/						
Beef	51	< .01	< .01	< .01	51	100
Pork	11	< .01	< .01	< .01	11	100
Hand-deboned beef	16	< .01	< .01	< .01	16	100

1/ Data from USDA study.

2/ Source of data: reference C-10.

3/ Calculated using data on poultry kidneys and assuming 50% yield of MDP from starting material. See text and appendix for calculation procedures. High values are for upper limit 90th percentile.

4/ Source of data: reference C-11.

5/ 8 samples contained 0.01 mcg/g of cadmium; 6 samples contained 0.02 mcg/g.

6/ 7 samples contained 0.01 mcg/g of cadmium.

7/ Geometric mean.

Table 5. Projected Maximum Daily Consumption by Infants of Cadmium from Mechanically Deboned Chicken (Fowl) 1/

Intake Class	Survey Year	Subjects Eating Chicken	Chicken Ingredients Consumed 2/	Cadmium Consumed from MDP made from Fowl 3/: Average Cd in MDP	Cadmium Consumed from MDP made from Fowl 3/: 90th Percentile Cd in MDP
		no.	g	mcg	mcg
50th percentile (median)	1972	208	3.2	0.44	1.12
	1974	79	3.0	.41	1.05
	1977	89	2.2	.30	.77
90th percentile	1972	208	12.5	1.71	4.36
	1974	79	13.5	1.85	4.71
	1977	89	11.0	1.51	3.84

1/ Source of data on consumption: reference C-6. Data not adjusted for frequency of consumption.

2/ Based on estimated percentage of cooked chicken in formulations of products. Products were estimated to contain from 3 to 57 percent cooked chicken. Values in this table are summarized from data on individual intakes, which varied widely in kinds, amounts, and numbers of different chicken products eaten.

3/ Assumes that MDP was made from raw fowl with kidneys in natural proportion and comprised 100 percent of the chicken ingredients. Values for cadmium in cooked MDP were calculated from values given in Appendix Table VI-1 for MDP made from raw fowl with kidneys, and assume a 70 percent yield with cooking. These values are (mcg per g): average cadmium, 0.137; 90th percentile cadmium, 0.349. Amounts of cadmium provided by MDP from turkey and from hand-deboned poultry would have been negligible (see Table 4) and have not been included in these estimates.

Table 6. Calcium Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Calcium Content		
		Average	Low	High
	No.	%	%	%
Mechanically deboned poultry:				
Cooked fowl frames 1/	26	0.209	0.097	0.335
Raw turkey frames 2/	5	.117	.052	.186
Raw chicken frames 2/	3	.175	.119	.250
Raw whole chicken carcasses 2/	1	.084	--	--
Raw whole turkey carcasses 2/	2	.048	.040	.055
Raw chicken parts 2/	23	.088	.051	.166
Raw turkey parts 2/	6	.090	.054	.139
Hand-deboned cooked fowl meat 1/	24	.020	ND	.055
Mechanically Processed (Species) Product: 3/				
Beef	30	.59	.24	1.10
Pork	23	.41	.12	.87

1/ Data from USDA study.

2/ Sources of data: references D-7, D-8, D-9, and D-10.

3/ Source of data: reference D-4.

Table 7. Calcium Content of Mechanically Deboned Poultry and Hand-Deboned Poultry

Product	Samples	Calcium Content Average	Low	High
	no.	%	%	%
Mechanically deboned poultry:				
Chicken (young):				
Frames, raw 1/	23	0.108	0.041	0.229
Frames, cooked 1/	14	.134	.060	.200
Parts, raw 1/ 2/	48	.122	.036	.317
Parts, cooked 1/	5	.055	.042	.070
Carcass, whole, raw 2/	1	.089	--	--
Chicken (mature)				
Frames, fowl, raw 1/	13	.213	.137	.349
Frames, fowl, cooked 1/	30	.265	.158	.487
Carcass, whole, stags, raw 1/	3	.077	.072	.081
Carcass, whole, fowl, cooked 1/	3	.212	.188	.226
Turkey (young):				
Frames, raw 1/ 3/	52	.146	.057	.255
Parts, raw 1/ 2/	8	.143	.090	.250
Carcass, whole, raw 2/	1	.155	--	--
Hand-deboned:				
Chicken (young):				
Light meat, raw 4/	24	.0116	.0083	.0156
Dark meat, raw 4/	24	.0123	.0083	.0166
Skin, raw 4/	24	.0105	.0076	.0133
Light meat cooked, dry heat 4/	16	.0150	.0107	.0188
Light meat, cooked, moist heat 4/	16	.0128	.0097	.0152
Dark meat, cooked, dry heat 4/	16	.0155	.0122	.0197
Dark meat, cooked, moist heat 4/	16	.0142	.0105	.0161
Skin, cooked, dry heat 4/	16	.0143	.0108	.0206
Skin, cooked, moist heat 4/	16	.0121	.0067	.0230
Chicken (fowl):				
Light and dark meat plus skin, raw 1/	3	.015	.013	.017
Light and dark meat plus skin, cooked 1/	3	.025	.022	.030
Turkey (young):				
Light meat, raw 4/	41	.0118	.0087	.0159
Dark meat, raw 4/	41	.0165	.0118	.0259
Skin, raw 4/	41	.0182	.0135	.0304
Light meat, cooked, dry heat 4/	41	.0186	.0106	.0321
Dark meat, cooked, dry heat 4/	41	.0317	.0199	.0547
Skin, cooked dry heat 4/	41	.0351	.0225	.0595
Whole, raw 1/	3	.009	.008	.010
Meat, cooked 1/	3	.024	.018	.035
Frame 3/	1	.005	--	--

1/ Source of data: reference D-1.
2/ Source of data: reference D-11.
3/ Source of data: reference D-12.
4/ Source of data: reference D-2.

Table 8. Fluoride Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Fluoride Content		
		Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry: 1/				
Fowl frames, cooked	26	14.38	3.25	25.25
Young chicken parts, raw	32	2.0	.9	3.9
Turkey parts, raw	29	1.7	.8	3.4
Hand-deboned poultry:				
Fowl meat, cooked 1/	25	.70	.40	1.88
Young chicken, raw:				
Breast meat 2/	10	.9	--	--
Leg and thigh meat 2/	10	.9	--	--
Breast 3/	25	.47	.29	.76
Thigh 3/	25	.32	.16	.48
Chicken broth 3/	5	.76	.55	1.04
Mechanically Processed (Species) Product: 4/				
Beef	20	18.6	7.8	32.5
Pork	22	11.0	2.3	25.0

1/ Data from USDA study.

2/ Source of data: reference E-18.

3/ Source of data: reference E-1.

4/ Source of data: reference E-9.

Table 9. Additional Data on Fluoride Content of Mechanically Deboned Poultry and Hand-Deboned Poultry

Product	Samples	Fluoride Content Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Chicken (young):				
Frames, raw 1/ 2/	26	1.34	0.57	2.20
Frames, cooked 1/	14	1.89	.40	3.10
Parts, raw 1/ 2/	64	1.37	<.40	3.30
Parts, cooked 1/	5	.65	<.40	1.10
Chicken (mature):				
Frames, fowl, raw 1/	13	10.18	3.72	23.25
Frames, fowl, cooked 1/	30	18.10	2.05	43.80
Parts, stag, raw 2/	4	1.44	1.20	1.69
Carcass, whole, stag, raw 1/	3	1.20	0.80	1.50
Carcass, whole, fowl, cooked 1/	3	15.20	12.80	17.20
Turkey (young):				
Frames, raw 1/	50	1.77	<40	3.30
Parts, raw 1/ 3/	9	2.16	1.02	4.94
Hand-deboned poultry:				
Fowl:				
Light meat, dark meat, and skin, raw 1/	3	.85	.70	.96
Meat, cooked 1/	3	1.38	.90	1.63
Turkey:				
Light meat, raw 1/	2	.52	.50	.53
Dark meat, raw 1/	2	.56	.47	.64
Whole, raw 1/	3	.86	.75	.94
Meat, cooked 1/	3	.95	.85	1.14
Baby food, strained:				
Chicken, avg. of 3 brands 4/	16	2.08	.57	3.58
Chicken, brand 1 5/	7	1.82	unknown	unknown
Chicken, brand 2 5/	5	.19	unknown	unknown
Chicken with chicken broth 6/	4	5.29	1.94	10.64
Turkey, 1 brand 4/	3	.64	.57	.69
Turkey, with vegetables, brand 1 5/	3	.20	unknown	unknown
Turkey with turkey broth 6/	2	.39	.34	.43

1/ Source of data: reference E-2.
2/ Source of data: reference E-3.
3/ Source of data: reference E-4.
4/ Source of data: reference E-7.
5/ Source of data: reference E-5.
6/ Source of data: reference E-6.

Table 10. Fluoride Content of Three Types of Mechanically Deboned Poultry from Different Geographic Areas

Product	Geographic Area of Source [1/]	Samples	Fluoride Content [2/]		
			Average	Low	High
		No.	mcg/g	mcg/g	mcg/g
Broiler backs, raw	West	3	1.62	1.52	1.69
	East	3	1.13	.40	2.30
	South	18	1.61	.98	3.30
Fowl frames, cooked	Midwest	17	20.1	6.9	34.4
	East	5	16.4	9.0	24.5
	South	8	14.7	2.05	43.8
Young turkey frames, raw	West	14	1.83	1.30	3.30
	Midwest	18	2.00	1.33	3.30
	East	1	2.40	--	--
	South	5	1.62	1.10	2.50

1/ Geographic areas include the following states:

West - California, Colorado, Utah.
Midwest - Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota. One composite sample was from Missouri and Mississippi, and a second composite sample was from Illinois, Missouri, and Mississippi.
East - Delaware, Maryland, New Jersey, Pennsylvania.
South - Arkansas, Georgia, North Carolina, South Carolina, Tennessee, Texas. Twelve samples of cooked fowl frames were described only as being from the Southeast.

2/ Source of data: reference E-2.

Table 11. Projected Maximum Daily Consumption by Infants of Fluoride from Mechanically Deboned Poultry 1/

Intake Class	Survey Year	Subjects Eating Poultry	Age	Cooked Poultry Ingredients Consumed 2/	Fluoride Consumption from Poultry Products 3/		
					Using Young Chickens and Turkey	Using Mature Fowl and Turkey	Using Hand-deboned Poultry
		no.	no.	g	mcg	mcg	mcg
50th percentile (median)	1972	234	7.6	4.5	17.1	83.7	3.6
	1974	95	7.8	3.5	13.3	65.1	2.8
	1977	116	7.6	2.2	8.4	40.9	1.8
90th percentile	1972	234	-	13.5	51.3	251.1	10.8
	1974	95	-	15.0	57.0	279.0	12.0
	1977	116	-	10.8	41.0	200.9	8.6

1/ Source of data on consumption: reference E-13. Data not adjusted for frequency of consumption.

2/ Based on estimated percentage of cooked poultry in formulations of products. Poultry ingredients were approximately 75 percent chicken and 25 percent turkey. Hand-deboned chicken was estimated to be 59 percent young chicken and 41 percent fowl.

3/ Assumes that MDP comprised 100 percent of poultry ingredients and that cooked MDP contained fluoride (mcg/g) as follows: young chicken with skin or turkey with skin, 3.8 (90th percentile value); mature fowl 23.5 (90th percentile value); and hand-deboned cooked poultry, 0.8 (average value calculated using proportions in footnote 2). Values for young chicken and turkey were calculated from data on raw products (Appendix tables III-2 and III-3), assuming a yield of 70 percent cooked chicken and no loss of fluoride. The weighted value for fluoride in mechanically deboned mature fowl and turkey was calculated to be 18.6 mcg/g.

Table 12. Lead Content of Mechanically Deboned Poultry Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Lead Content			Samples Below Detectability Limit
		Average	Low	High	
	no.	mcg/g	mcg/g	mcg/g	no.
Mechanically deboned poultry: 1/					
Cooked fowl frames	26	0.05	<0.01	0.22	9
Raw chicken parts	31	<.01	< .01	.08	28
Raw turkey parts	26	<.01	< .01	<.01	26
Hand-deboned cooked fowl meat	25	.02	< .01	.08	17
Poultry kidneys: 2/					
Chicken (young)	100	.07	.02	.20	0
Chicken (old)	100	.06	.03	.23	0
Mechanically processed (species) product: 3/					
Beef	14	.09	.06	.15	--
Pork	16	.06	<.05	.15	--
Mechanically deboned poultry from broiler backs: 4/					
Made with kidneys with average lead contents	---	<.01	---	---	---
Made with kidneys with maximum lead contents	---	.01	---	---	---

1/ Data from USDA study. Limit of detectability for lead was 0.01 mcg/g. Samples were analyzed by modified atomic absorption spectrophotometry (reference F-7).
2/ Geometric means. Analyses by anodic stripping voltammetry. Data from USDA study.
3/ Source of data: reference F-8. Limits of detectability for lead was 0.05 mcg/g.
4/ Calculated values, assuming 50% yield of MDP and presence of kidneys as 4 percent of backs by weight.

Table 13. Additional Data on Lead Content of Mechanically Deboned Poultry and Hand-Deboned Poultry

Product	Samples	Lead Content: Average	Lead Content: Low	Lead Content: High	Samples Below Detectability Limits 1/
	no.	mcg/g	mcg/g	mcg/g	no.
Mechanically deboned poultry:					
Chicken (young):					
Frames, raw 2/ 3/	18	0.06	.01	.13	3/ 1
Frames, cooked 2/	6	.01	<.01	.01	3
Parts, raw 2/ 3/	44	.06	<.01	.12	3/ 9
Parts, cooked 2/	3	<.01	<.01	<.01	3
Chicken (mature):					
Frames, fowl, raw 2/	6	<.09	.07	.11	3/ 3
Frames, fowl, cooked 2/	27	.08	.01	.14	3/ 3
Carcass, stag, whole, raw 3/	3	.05	.03	.07	0
Carcass, fowl, whole, cooked 2/	3	<.1	<.1	<.1	3/ 3
Turkey (young): 2/					
Frames, raw	51	.08	0.	.26	3/ 18
Parts, raw	4	.09	.04	.24	3/ 1
Hand-deboned poultry: 2/					
Fowl, light and dark meat plus skin, cooked	3	.09	.09	.10	0
Turkey, (young), meat, cooked	3	<.09	<.09	<.09	3

1/ Three limits of detectability -- 0.01, 0.06, and 0.1 mcg/g -- were reported for these samples.
2/ Source of data: reference F-2.
3/ Source of data: reference F-9.

Table 14. Projected Maximum Daily Intakes by Children of Lead from Mechanically Deboned Poultry or Mechanically Processed (Species) Product 1/

Child's age, years	0 - 2	3 - 5	6 - 12
Body wt., kg	12.2	17.9	32.7
Acceptable Daily Intake of lead, mcg	2/100-150	2/200	3/229
Lead intakes per day from specified product			
MP(S)P, 20% usage level, mcg 4/	.24	.31	.62
MDP, 20% usage level, mcg 5/	.22	.29	.57
Hand-deboned poultry, 20% usage level 6/	.04	.05	.10
MDP, 100% usage level, mcg 5/	1.12	1.45	2.85
Hand-deboned poultry, 100% usage level 7/	.19	.24	.47

1/ Intakes at 90th percentile of product intake with 90th percentile contents of lead in MP(S)P and MDP from cooked fowl frames, and average lead contents of hand-deboned poultry. These contents are (mcg/g): beef MP(S)P, 0.13; pork MP(S)P, 0.10; MDP from cooked fowl frames, 0.12; hand-deboned cooked fowl, 0.02. Assumes presence of MP(S)P and MDP in baby foods.

2/ FDA estimates of permissible daily intakes (reference F-1).

3/ WHO provisional tolerance for adults (reference F-1).

4/ Source of data: reference F-4.

5/ Assumes that products containing MDP are eaten in amounts equal to estimated intakes of MP(S)P. (Reference F-4).

6/ Estimated amounts of hand-deboned poultry that would be replaced by MDP at a 20% usage level.

7/ Estimated amounts of hand-deboned poultry that would be replaced by MDP at a 100% usage level.

Table 15. Projected Maximum Daily Consumption by Infants of Lead from Hand-Deboned Cooked Fowl Meat and Mechanically Deboned Chicken (Fowl) 1/

Intake Class	Survey Year	Subjects Eating Chicken	Chicken Ingredients Consumed 2/	Lead Consumed from Hand-Deboned Cooked Fowl Meat 3/		Lead Consumed from MDP Made from Cooked Fowl 4/	
				Average Lead in HDP	90th Percentile Lead in HDP	Average Lead in MDP	90th Percentile Lead in MDP
		no.	g	mcg	mcg	mcg	mcg
50th percentile (median)	1972	208	3.2	0.06	0.19	0.16	0.38
	1974	79	3.0	.06	.18	.15	.36
	1977	89	2.2	.04	.13	.11	.26
90th percentile	1972	208	12.5	.25	.75	.62	1.50
	1974	79	13.5	.27	.81	.68	1.62
	1977	89	11.0	.22	.66	.55	1.32

1/ Source of data on consumption: reference F-5. Data not adjusted for frequency of consumption.

2/ Based on estimated percentage of cooked chicken in formulations of products. Products were estimated to contain 3 to 57 percent cooked chicken. Values in this table are summarized from data on individual intakes, which varied widely in kinds, amounts, and numbers of different poultry products eaten.

3/ Assumes that hand-deboned chicken was all from cooked fowl meat, and contained lead (mcg/g) as follows: average, 0.02; 90th percentile, 0.06.

4/ Assumes that MDP was made from cooked fowl frames, comprised 100 percent of the chicken ingredients, and contained lead (mcg/g) as follows: average, 0.05; 90th percentile, 0.12. Amounts of lead provided by MDP from turkey would have been negligible (see Table 12) and have not been included in these estimates.

Table 16. Selenium Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Selenium Content		
		Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Cooked fowl frames 1/	26	0.14	0.05	0.32
Cooked fowl frames 2/	5	.08	.04	.12
Cooked chicken frames 3/	10	.19	.06	.43
Raw broiler parts 2,4/	7	.14	N.D.	.27
Raw turkey frames 3,4/	3	.11	N.D.	.21
Hand-deboned poultry:				
Cooked fowl meat 1/	25	.19	.07	.32
Raw chicken breast and leg 5/	4	.13	.11	.15
Raw chicken skin 5/	2	.15	.15	.15
Mechanically processed (species) product 6/:				
Beef	29	.07	< .05	.14
Pork	23	.11	< .05	.28

1/ Data from USDA study. Determined by atomic absorption spectrophotometry following ashing in a graphite furnace.
2/ Source of data: reference G-4. Determined by atomic absorption.
3/ Source of data: reference G-5. Determined by neutron activation analysis.
4/ Source of data: reference G-6. Determined by neutron activation analysis.
5/ Source of data: reference G-7. Determined by fluorometry.
6/ Source of data: reference G-8. Determined as described in footnote 1.

Hand Deboned Poultry and Mechanically Processed (Species) Product

Product	Samples	Strontium-90 Content					
		Average	Low	High	Average	Low	High
	no.	pCi/kg	pCi/kg	pCi/kg	pCi/g Ca	pCi/g Ca	pCi/g Ca
Mechanically deboned poultry:							
Cooked fowl frames 1/	8	2.5	1.0	4.3	1.8	0.8	3.6
Raw chicken parts 2/	1	(27.3)	--	--	22.4	--	--
Raw turkey 3/	5	12.2	1.2	30.2	(10.4)	--	--
Hand-deboned cooked fowl meat 1/	2	0.4	0.4	0.5	4.2	3.3	5.0
Mechanically processed (species) product: 4/							
Beef	19	77	22	208	13.4	3.8	30.3
Pork	1	29	--	--	6.1	--	--
Milk:							
1964, July, 63 cities 5/	63	25.5	2.9	61.0	21.4	2.4	51.3
1977, July, 64 cities 6/	65	3.7	< .1	8.8	3.1	< .1	7.4
1978, July, 65 cities 7/	65	3.9	.5	8.5	3.3	.4	7.2

1/ Data from USDA study. Analyses were made by the Health and Safety Laboratory, Energy Research and Development Admin.
2/ Source of data: reference H-3. Value was no different from background, according to the investigator reporting the results. Value for pCi per kg was calculated, assuming a calcium content of 0.122% as reported for raw chicken parts in Table 7.
3/ Source of data: reference H-4. Values were no different from background, according to the analysts reporting the data. Value for pCi per gram of calcium was calculated, assuming calcium content of 0.177 percent as reported for raw turkey frames in Table 6.
4/ Source of data: reference H-12.
5/ Source of data: reference H-11. Values were recalculated as in footnote 6.
6/ Source of data: reference H-9. Values were recalculated from pCi per liter of milk, assuming a specific gravity for milk of 1.032 kg per liter and a calcium content of 1.190 g per kg (reference H-13).
7/ Source of data: reference H-10. Values were recalculated as in footnote 6.

Table 18. Average Estimated Daily Intakes of Strontium-90 Among Various Age Groups of Eaters of Products Containing Mechanically Processed (Species) Product or Mechanically Deboned Poultry 1/

Age Group	Body Weight	20 Percent Usage Level 2/				100 Percent Usage Level 2/		
		Intake of MP(S)P or MDP 3/		Intake of Sr-90 From MP(S)P 4/	Intake of Sr-90 From MDP 5/	Intake of MDP 6/		Intake of Sr-90 From MDP 5/
years	kg	mg/kg	g/day	pCi/day	pCi/day	mg/kg	g/day	pCi/day
0 - 2	12.194	51.82	0.632	0.049	0.0038	259.1	3.16	0.0189
3 - 5	17.911	62.46	1.119	.086	.0067	312.3	5.60	.0336
6 -12	32.710	62.54	2.046	.158	.0123	312.7	10.23	.0614
13-17	56.129	47.22	2.650	.204	.0159	236.1	13.25	.0795
18-24	65.310	36.56	2.388	.184	.0143	182.8	11.94	.0716
25-44	70.153	32.56	2.284	.176	.0137	162.8	11.42	.0685
45+	71.325	25.97	1.852	.143	.0111	129.8	9.26	.0556

1/ Source of data for body weights, intakes of MP(S)P, and intakes of Sr-90 from MP(S)P: reference H-6.

2/ Usage level is the percentage comprised by MP(S)P or MDP of total meat, meat byproducts, poultry, or poultry products ingredients in finished meat or poultry products, by weight of formulation.

3/ Assumes the quantity of MDP eaten is equal to the quantity of MP(S)P eaten.

4/ Assumes an average content of 0.077 pCi Sr-90 per gram of MP(S)P.

5/ Assumes an average content of 0.0060 pCi Sr-90 per gram of MDP. Value is based on MDP consisting of 64% chicken product (0.0025 pCi Sr-90 per gram) and 36% turkey product (0.0122 pCi Sr-90 per gram).

Table 19. Cobalt Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Cobalt Content		
		Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Cooked fowl frames 1/	26	0.13	0.06	0.18
Raw broiler parts 2/	6	.07	.03	.11
Raw broiler frames 2/	2	.12	.08	.15
Raw turkey frames 2/	11	.08	.02	.23
Cooked broiler frames 2/	3	.15	.13	.17
Hand-deboned poultry:				
Cooked fowl meat 1/	24	.11	.03	.26
Mechanically processed (species) product: 3/				
Beef	16	.29	.18	.56
Pork	13	.23	.13	.50

1/ Data from USDA study. Determined by atomic absorption spectrophotometry (AAS).

2/ Source of data: references I-5 and I-6. Determined by neutron activation analysis.

3/ Source of data: reference I-7. Determined by AAS.

Table 20. Copper Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Copper Content Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Cooked fowl frames [1]	26	0.69	.51	1.13
Cooked fowl frames [2]	5	.54	.17	.77
Raw broiler parts [3]	3	.58	.41	.69
Raw broiler frames [3]	1	.63	--	--
Hand deboned poultry:				
Cooked fowl meat [1]	23	.80	.51	1.00
Raw chicken (flesh without skin) [4]	24	.53	--	--
Baked chicken (flesh without skin) [4]	16	.67	--	--
Stewed chicken (flesh without skin) [4]	16	.61	--	--
Raw chicken (light and dark meat) [5]	9	.18	.01	.41
Raw turkey (light and dark meat) [5]	4	.11	.04	.20
Mechanically processed (species) product: [6]				
Beef	16	.54	.26	.81
Pork	13	.70	.57	.92

[1] Data from USDA study. Determined by atomic absorption spectrophotometry (AAS).

[2] Source of data: reference J-6. Determined by AAS.

[3] Source of data: reference J-10. Determined by AAS.

[4] Source of data: reference J-5. Determined by AAS.

[5] Source of data: reference J-4. Compiled data. Methods of analysis not stated.

[6] Source of data: reference J-11. Determined by AAS.

Table 21. Iron Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Iron Content		
		Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Cooked fowl frames 1/	24	43.8	18	91
Cooked fowl frames 2/	5	20.8	18.5	23.0
Raw broiler frames 3/	6	30.3	20.6	45
Raw broiler parts 4/	27	23.5	12.7	65.6
Raw fowl 5/	6	12.2	---	---
Raw turkey frames 6/	23	42.7	16.1	91.76
Raw turkey parts 5/	6	16.5	---	---
Hand-deboned poultry:				
Cooked fowl frames 1/	24	67.0	15	174
Chicken, fryers: 7/				
Raw, flesh only	---	13	---	---
Cooked, flesh only	---	16	---	---
Chicken, roasters: 7/				
Raw, flesh only	---	13	---	---
Cooked, flesh only	---	15	---	---
Turkey, all classes: 7/				
Raw, flesh only	---	15	---	---
Cooked, flesh only	---	18	---	---
Mechanically processed (species) product: 8/				
Beef	16	40.9	20.4	56.3
Pork	13	19.9	13.0	26.9

1/ Data from USDA study.
2/ Source of data: reference K-13.
3/ Sources of data: references K-11, K-14 and K-15.
4/ Sources of data: references K-13, K-14, K-15, K-16 and K-17.
5/ Source of data: reference K-16.
6/ Sources of data: references K-15, K-16 and K-17.
7/ Source of data: reference K-18.
8/ Source of data: reference K-19.

Table 22. Probable Maximum Intakes of Iron from Mechanically Deboned Poultry (MDP) and Hand-Deboned Poultry (HDP) at Two Levels of Use 1/

Age Group	Body Weight (BW)	Iron RDA Per kg BW 2/	20% Usage Level 3/					100% Usage Level 3/				
			MDP 1/ Intake Per kg BW	Iron Intake from MDP		Iron Intake from HDP		MDP Intake 1/ Per kg BW	Iron Intake from MDP 5/		Iron Intake from HDP	
				Per kg BW	Per RDA	Per kg BW	Per RDA		Per kg BW	Per RDA	Per kg BW	Per RDA
years	kg	mcg	mg	mcg	%	mcg	%	mg	mcg	%	mcg	%
0 - 2	12.2	1230	153.5	12.7	1.0	18.3	1.5	767.5	63.5	5.2	91.5	7.4
3 - 5	17.9	559	135.0	11.2	2.0	16.1	2.9	675.0	56.0	10.0	80.5	14.4
6 -12	32.7	428	145.1	12.0	2.8	17.3	4.0	725.5	60.0	14.0	86.5	20.2
13-17	56.1	321	107.5	8.9	2.8	12.8	4.0	537.5	44.5	13.9	64.0	19.9
18-24	65.3	4/153-276	96.4	8.0	5.2-2.9	11.5	7.5-4.2	482.0	40.0	26.1-14.5	57.5	37.6-20.8
25-44	70.2	4/142-256	80.6	6.7	4.7-2.6	9.6	6.8-3.8	403.0	33.5	23.6-13.1	48.0	33.8-18.8
45+	71.3	140	65.2	5.4	3.9	7.8	5.6	326.0	27.0	19.3	39.0	27.9

1/ Assumes intakes of MDP from cooked fowl frames equal to intakes of MP(S)P (K-1). Assumes that MDP is present in baby foods and that iron is present in MDP at the 90th percentile level. These contents are (mcg/g): MDP (cooked fowl frames), 83; hand-deboned poultry (cooked fowl), 119.

2/ Recommended dietary allowances (K-2) were adjusted for age ranges (K-1).

3/ Usage level is the percentage comprised by MP(S)P and MDP of total meat, meat byproducts, poultry or poultry products, by weight of formulation. For hand-deboned poultry, usage level represents the iron intake which would be replaced by iron consumed from MDP.

4/ First value for males; second values for females.

5/ Assumes the same total weight of meat or poultry products containing MDP is eaten as at 20% usage level.

Table 23. Nickel Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Samples	Average	Low	High
	no.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Cooked fowl frames 1/	22	0.53	0.15	2.84
Cooked fowl frames 2/	5	.8	.8	.8
Raw broiler parts 2/	1	.7	--	--
Hand-deboned cooked fowl meat 1/	21	.35	.10	.60
Mechanically processed (species) product: 3/				
Beef	18	.33	.20	.58
Pork	15	.33	.18	.56

1/ Data from USDA study. Analyses by atomic absorption spectrophotometry.

2/ Source of data: reference L-12. Analyses by atomic absorption spectrophotometry.

3/ Source of data: reference L-4, page 36.

Table 24. Probable Maximum Intakes of Nickel from Mechanically Processed (Species) Product and Mechanically Deboned Poultry 1/

Age Group	Body Weight (BW)	Typical Nickel Intake 2/		20 Percent Usage Level 3/					100 Percent Usage Level 3/		
		Per day	Per kg BW	Intake of MP(S)P or MDP per kg BW 4/	Projected Intake of Nickel From MP(S)P 5/ Per kg BW	Projected Intake of Nickel From MP(S)P 5/ Per Typical Intake	Projected Intake of Nickel From MDP 5/ Per kg BW	Projected Intake of Nickel From MDP 5/ Per Typical Intake	Intake of MDP per kg BW	Projected Intake of Nickel from MDP 5/ Per kg BW	Projected Intake of Nickel from MDP 5/ Per Typical Intake
years	kg	mcg	mcg	mg	mcg	%	mcg	%	mg	mcg	%
0 - 2	12.2	--	(4.27)	153.5	0.068	(1.6)	0.215	5.0	767.5	1.075	25.2
3 - 5	17.9	--	(4.27)	135.0	.059	(1.4)	.189	4.4	675.0	.945	22.1
6 -12	32.7	--	(4.27)	145.1	.064	(1.5)	.203	4.8	725.5	1.015	23.8
13-17	56.1	--	(4.27)	107.5	.047	(1.1)	.150	3.5	537.5	.750	17.6
18-24	65.3	--	(4.27)	96.4	.042	(1.0)	.135	3.2	482.0	.675	15.8
25-44	70.2	300	4.27	80.6	.035	.8	.113	2.6	403.0	.565	13.2
45+	71.3	300	4.21	65.2	.029	.7	.091	2.2	326.0	.455	10.8

1/ Source of data for body weights, intakes of MP(S)P, and intakes of nickel from MP(S)P: reference L-1.

2/ Based on estimates of intakes for U.S. adults as given in references L-5, L-6, and L-7. Typical daily intakes of nickel are probably underestimates for infants and young children because of their greater energy intake per unit of body weight.

3/ Percent of total meat or poultry ingredients in products.

4/ Assumes intakes of MDP equal to those of MP(S)P. Further assumes intakes of MP(S)P or MDP at the 90th percentile level (L-4) for eaters of products containing MP(S)P or MDP, and that MP(S)P or MDP are present in baby foods.

5/ Assumes that nickel is present in MP(S)P or MDP at the 90th percentile level. These contents are (mcg/g): MP(S)P (beef), 0.44; MP(S)P (pork), 0.49; and MDP (cooked fowl frames) 1.4.

Table 25. Zinc Content of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Mechanically Processed (Species) Product

Product	Analyses	Zinc Content		
		Average	Low	High
	No.	mcg/g	mcg/g	mcg/g
Mechanically deboned poultry:				
Cooked fowl frames, 1/	26	18.6	12.2	34.0
Raw broiler parts 2/	26	18.1	12.0	24.0
Raw broiler frames 3/	3	15.9	11.6	18.
Cooked broiler frames 4/	3	22.7	21.	25.
Raw fowl 5/	6	19.0	--	--
Raw turkey parts 5/	6	31.3	--	--
Raw turkey frames 6/	23	26.9	21.5	35.5
Hand-deboned poultry:				
Cooked fowl meat 1/	24	13.8	7.8	19.6
Chicken meat, raw 7/	--	12	--	--
Chicken meat, cooked 7/	--	18	--	--
Turkey meat, raw 7/	--	24	--	--
Turkey meat, cooked 7/	--	32	--	--
Mechanically processed (species) product: 8/				
Raw beef	30	34.2	20.7	59.4
Raw pork	23	23.2	13.0	27.9

1/ Data from USDA study.
2/ Source of data: references M-3, M-4, M-5, and M-6.
3/ Source of data: references M-3 and M-4.
4/ Source of data: reference M-4.
5/ Source of data: reference M-6.
6/ Source of data: references M-4, M-5, and M-6.
7/ Source of data: reference M-7. Values tabulated here are averages for light and dark meat, without skin.
8/ Source of data: reference M-8.

Table 26. Probable Maximum Intakes of Zinc from Mechanically Processed (Species) Product and Mechanically Deboned Poultry [1/]

Age Group	Body Weight (BW)	Zinc RDA Per kg BW [2/]	20 Percent Usage Level [3/]					100 Percent Usage Level [3/]		
			Intake of MP(S)P or MDP per kg BW [4/]	Intake of Zinc [5/]				Intake of MDP per kg BW	Intake of Zinc [5/]	
				From MP(S)P		From MDP			from MDP	
				Per kg BW	Per RDA	Per kg BW	Per RDA		Per kg BW	Per RDA
years	kg	mcg	mg	mcg	%	mcg	%	mg	mcg	%
0 - 2	12.2	615	153.5	7.184	1.2	3.838	0.6	767.5	19.19	3.1
3 - 5	17.9	559	135.0	6.317	1.1	3.375	.6	675.0	16.88	3.0
6 -12	32.7	459	145.1	6.792	1.5	3.628	.8	725.5	18.14	4.0
13-17	56.1	267	107.5	5.030	1.9	2.688	1.0	537.5	13.44	5.0
18-24	65.3	230	96.4	4.511	2.0	2.410	1.0	482.0	12.05	5.2
25-44	70.2	214	80.6	3.770	1.8	2.015	.9	403.0	10.08	4.7
45+	71.3	210	65.2	3.053	1.4	1.630	.8	326.0	8.15	3.9

1/ Source of data for body weights, intakes of MP(S)P, and intakes of zinc from MP(S)P: reference M-1.

2/ Recommended dietary allowances (M-2) were adjusted for age ranges (M-1).

3/ Percent of total meat or poultry ingredients in products.

4/ Assumes intakes of MDP equal to intakes of MP(S)P (M-1) at the 90th percentile level of consumption. Assumes that MDP or MP(S)P are present in baby foods.

5/ Assumes that zinc is present in MP(S)P or MDP at the 90th percentile level. These contents are (mcg/g): MP(S)P (beef), 46.8; MP(S)P (pork), 27.6 (M-7); MDP (cooked fowl frames), 25.0.

Table 27. Levels of Chlorinated Hydrocarbons in Fat from Mechanically Deboned Poultry and from Hand-Deboned Poultry

Type of Tissue	Residue Level in Micrograms Per Gram of Fat: Not Detected (N.D.)	.01 - .3	.31 - 1.0	1.0 +	Total	Highest Amount Found	Tolerance or Action Level 1/
	no.	no.	no.	no.	no.	mcg/g	
			Benzene Hexachloride (BHC)				0.3
Mechanically deboned poultry:							
Cooked fowl frames	2/ 25(100)	0	0	0	25	N.D.	
Raw chicken parts	4(80)	1(20)	0	0	5	.04	
Raw turkey parts	6(100)	0	0	0	6	N.D.	
Fat from hand-deboned poultry:							
Cooked fowl meat	25(100)	0	0	0	25	N.D.	
Chicken	892(96)	35(4)	0	0	927	---	
Turkey	412(90)	44(10)	0	0	456	---	
			Dieldrin				0.3
Mechanically deboned poultry:							
Cooked fowl frames	15(58)	11(42)	0	0	26	.02	
Raw chicken parts	1(20)	4(80)	0	0	5	.06	
Raw turkey parts	2(33)	4(67)	0	0	6	.21	
Fat from hand-deboned poultry:							
Cooked fowl meat	13(52)	12(48)	0	0	25	.02	
Chicken	347(37)	580(63)	0	0	927	---	
Turkey	111(24)	345(76)	0	0	456	---	
			DDT				5.0
Mechanically deboned poultry:							
Cooked fowl frames	1(4)	23(88)	2(8)	0	26	0.33	
Raw chicken parts	0	5(100)	0	0	5	.02	
Raw turkey parts	1(17)	2(33)	3(50)	0	6	.53	
Fat from hand-deboned poultry:							
Cooked fowl meat	1(4)	23(92)	1(4)	0	25	.33	
Chicken	164(18)	722(78)	40(4)	1(.1)	927	---	
Turkey	33(7)	381(84)	40(9)	2(.2)	456	---	
			Heptachlor				0.3
Mechanically deboned poultry:							
Cooked fowl frames	26(100)	0	0	0	26	N.D.	
Raw chicken parts	5(100)	0	0	0	5	N.D.	
Raw turkey parts	4(67)	2(33)	0	0	6	.12	
Fat from hand-deboned poultry:							
Cooked fowl meat	25(100)	0		0	25	N.D.	
Chicken	828(89)	97(10)	2(0.2)	0	927	---	
Turkey	370(81)	86(19)	0	0	456	---	
			Hexachlorobenzene (HBC)				0.5
Mechanically deboned poultry:							
Cooked fowl frames	26(100)	0	0	0	26	N.D.	
Raw chicken parts	5(100)	0	0	0	5	N.D.	
Raw turkey parts	4(67)	2(33)	0	0	6	.06	
Fat from hand-deboned poultry:							
Cooked fowl meat	24(96)	1(4)	0	0	25	.08	
Chicken	759(87)	168(18)	0	0	927	----	
Turkey	257(56)	199(44)	0	0	456	---	

1/ Tolerance or action levels are established by or with the advice of the Environmental Protection Agency (See text).

2/ Number in parentheses is the percent of total samples.

Table 28. Cholesterol Content of Mechanically Deboned Poultry and Hand-deboned Poultry

Poultry Product	Samples	Cholesterol Average	Cholesterol Low	Cholesterol High
	no.	mg/100g	mg/100g	mg/100g
Mechanically deboned poultry:				
Cooked fowl frames 1/	8	140	110	169
Raw chicken parts 1/	5	120	97	148
Raw turkey parts 1/	5	97	86	105
Raw chicken frames 2/	2	120	110	130
Raw chicken parts 2/	2	160	150	170
Cooked chicken parts 2/	2	135	130	140
Raw turkey 2/	2	110	110	110
Hand-deboned poultry:				
Cooked fowl meat 1/	8	64	46	79
Chicken, flesh only: 3/				
Raw	8	70	47	81
Cooked	4	89	78	110
Chicken, skin only: 4/				
Raw	8	109	97	121
Cooked	4	91	85	96
Turkey, flesh only: 5/				
Raw	41	66	47	78
Cooked	41	79	60	121
Turkey, skin only: 4/				
Raw	41	97	66	161
Cooked	41	117	89	171

1/ Data from USDA study.

2/ Source of data: reference 0-24.

3/ Source of data: reference 0-22, combined data for breast and drumstick meat.

4/ Source of data: reference 0-22.

5/ Source of data: reference 0-22, combined data for light and dark meat.

Table 29. Probable Maximum Increases in Intakes of Cholesterol if Mechanically Processed (Species) Product or Mechanically Deboned Poultry Replaced Hand-deboned Meat or Poultry 1/

Age Group	Body Weight (BW)	20 Percent Usage Level 2/					100 Percent Usage Level 2/		
		Intake of MP(S)P or MDP per kg BW 3/	Increase in Cholesterol Intake 4/				Intake of MDP per kg BW	Increase in Cholesterol Intake From MDP 4/	
			From MP(S)P		From MDP				
			per kg BW	per day	per kg BW	per day		per kg BW	per day
years	kg	mg	mg	mg	mg	mg	mg	mg	mg
0 - 2	12.2	153.5	0.12	1.5	0.16	1.9	767.5	0.81	9.5
3 - 5	17.9	135.0	.10	1.9	.14	2.6	675.0	.72	13.0
6 -12	32.7	145.1	.12	3.7	.15	5.0	725.5	.74	25.0
13-17	56.1	107.5	.08	4.8	.11	6.2	537.5	.56	31.0
18-24	65.3	96.4	.08	5.0	.10	6.6	482.0	.49	33.0
25-44	70.2	80.6	.07	4.4	.09	5.9	403.0	.44	29.5
45 +	71.3	65.2	.05	3.7	.07	4.8	326.0	.34	24.0

1/ Source of data for body weights and intakes of MP(S)P: reference 0-19.

2/ Percent of total meat or poultry ingredients in products.

3/ Assumes that intakes of MDP are equal to 90th percentile intakes of MP(S)P (ref 0-19). Assumes that MP(S)P or MDP are present in baby foods.

4/ Assumes that cholesterol is present in MP(S)P and MDP at the 90th percentile levels and hand-deboned beef and poultry at average levels. These contents are (mg/100g): beef MP(S)P, 144; MDP from cooked fowl frames, 168; hand-deboned beef, 65; and hand-deboned cooked fowl meat 64.

Table 30. Projected Maximum Daily Consumption by Infants of Cholesterol from Hand-deboned Cooked Poultry and Mechanically Deboned Cooked Poultry 1/

Intake Class	Survey Year	Subjects Eating Poultry	Cooked Poultry Ingredients Consumed 2/	Cholesterol Consumption From Poultry Products 3/		
				Using HDP	Using MDP	Increase
				mg	mg	mg
50th percentile (median)	1972	234	4.5	3.6	8.2	4.6
	1974	95	3.5	2.8	6.4	3.6
	1977	116	2.2	1.7	4.0	2.3
90th percentile	1972	234	13.5	10.7	24.7	14.0
	1974	95	15.0	11.8	27.4	15.6
	1977	116	10.8	8.5	19.8	11.3

1/ Source of data on consumption: reference 0-17. Data not adjusted for frequency of consumption.

2/ Based on estimated percentage of cooked poultry in formulations of products. Poultry ingredients were approximately 75 percent chicken and 25 percent turkey. Chicken was estimated to be 59 percent young chicken and 41 percent fowl.

3/ Assumes that MDP comprised 100 percent of poultry ingredients. Using percentages given in footnote 2, weighted values for cholesterol content were calculated. For MDP, the high values for cholesterol in cooked fowl, young chicken and turkey were used; for hand-deboned poultry, the average values were used. Values for young chicken and turkey were calculated from data on raw products (Table 28), assuming a yield of 70 percent cooked product and no loss of cholesterol. The weighted cholesterol contents (mg/100g) were as follows: MDP, 183 and hand-deboned poultry, 79.

Table 31. Fatty Acid Content of Total Lipids from Mechanically Deboned Poultry and Hand-deboned Poultry

Product	Total Lipids	Total Fatty Acids in Lipids	Fatty Acids Content of 100 grams of Total Lipids 1/											
			Saturated				Monounsaturated			Polyunsaturated				Other 2/
			12:0	14:0	16:0	18:0	14:1	16:1	18:1	18:2	18:3	20:4	22:6	Total
	%	%	g	g	g	g	g	g	g	g	g	g	g	g
Mechanically deboned poultry:														
Cooked fowl frames 3/	15.7	5/93.0	---	0.7	16.7	5.4	0.2	4.0	41.8	20.6	1.4	0.5	0.1	1.6
Raw chicken frames 4/	16	5/90	---	.8	18.3	6.2	.2	5.4	36.5	18.3	1.0	1.4	---	1.9
Raw chicken parts 6/	27	5/92.4	---	1.2	20.2	7.3	.1	.2	36.2	19.3	1.5	.4	---	6.0
Raw chicken parts 7/	16.3	5/93	---	.8	22.1	6.8	---	5.5	42.3	14.4	1.1	---	---	---
Raw fowl 8/	20.4	5/93	---	.8	19.7	3.8	---	5.0	42.3	20.6	.7	---	---	---
Raw turkey frames 8/	13.9	5/93	0.8	1.7	21.4	9.9	---	1.5	29.9	25.8	1.9	---	---	0
Raw turkey parts 9/	20.6	5/93	.6	1.4	19.9	11.1	---	1.9	30.6	26.0	1.7	---	---	---
Hand-deboned chicken:														
Cooked fowl meat 3/	5.7	90.3	---	.7	16.8	5.5	.2	3.6	38.5	20.2	1.2	1.1	.3	2.2
Light meat 10/	11/1.0 R, 3.5 C	81	---	.6	20.1	8.3	1.1	2.6	22.0	15.8	.6	4.5	3.0	2.4
Dark meat 10/	4.0 R, 9.7 C	86	---	.9	19.5	7.1	1.1	4.3	27.9	19.5	.9	2.9	.9	.8
Skin 10/	25.2 R, 29.7 C	94	---	1.1	22.3	5.6	0	5.9	33.1	23.8	1.6	.6	0	---
Hand-deboned turkey: 12/														
Light meat	11/1.1 R, 2.6 C	81	.6	.6	17.0	8.9	---	4.2	18.2	19.9	1.1	4.3	2.3	3.9
Dark meat	3.2 R, 5.3 C	85	---	.8	18.2	8.2	---	5.5	21.3	20.9	1.3	2.3	3.2	3.3
Skin	34.9 R, 37.0 C	95	---	.8	18.7	5.6	---	7.3	35.0	24.7	2.0	---	---	.9
Chicken bone marrow 13/	46.5	5/93.6	---	.8	20.3	8.8	---	3.3	32.4	23.5	1.4	.9		2.2

1/ 12:0 = lauric; 14:0 = myristic; 16:0 = palmitic; 18:0 = stearic; 14:1 = myristoleic; 16:1 = palmitoleic; 18:1 = oleic; 18:2 = linoleic; 18:3 = linolenic; 20:4 = arachidonic; 22:6 = docosahexaenoic.

2/ Other = the total of minor saturated and unsaturated fatty acids not reported elsewhere in the table.

3/ Data from USDA study.

4/ Source of data: reference O-25.

5/ Estimated value.

6/ Source of data: reference O-26. Recalculated, assuming that fatty acids were 95.6% of triglycerides and 72% of phospholipids in fat as per reference O-10.

7/ Source of data: reference O-27. Parts analyzed were necks and/or backs with and without skin.

8/ Source of data: reference O-27.

9/ Source of data: reference O-27. Parts analyzed were backs.

10/ Source of data: reference O-28.

11/ Total lipids data are given for raw (R) and cooked (C) poultry. Fatty acids contents were the same for raw and cooked poultry.

12/ Source of data: reference O-22.

13/ Source of data: reference O-12.

Table 32. Total Lipids Content of Mechanically Deboned Poultry and Hand-Deboned Poultry

Product	Source of Data	Samples	Total Lipids Average	Total Lipids Low	Total Lipids High
		o.	%	%	%
Mechanically deboned poultry:					
Cooked fowl frames	USDA, 1977	26	17.1	6.3	24.8
Raw chicken frames	USDA, 1974	2	22.2	21.4	23.0
Do........	References 0-24, 0-25, 0-29	7	14.1	11.5	16
Cooked chicken frames	Ref. 0-24	--	16.5	14.3	18.6
Raw turkey frames	USDA, 1974	5	13.0	7.4	20.8
Do........	Ref. 0-24, 0-27, 0-30, 0-31, 0-32, 0-33, 0-34	28	14.7	10.3	22.5
Raw chicken parts:					
With skin	USDA, 1977	20	22.4	15.2	30.2
Do......	USDA, 1974	6	24.3	16.4	32.4
Do......	Ref. 0-24, 0-26, 0-27, 0-33, 0-34, 0-35, 0-36, 0-37, 0-38	89	22.6	18.0	33.6
Without skin	USDA, 1977	11	14.6	11.6	18.3
Do......	USDA, 1974	3	10.5	7.0	16.4
Do......	Ref. 0-24, 0-27, 0-29, 0-34, 0-36, 0-38	51	15.5	7.9	18.5
Raw turkey parts:					
With skin	USDA, 1977	15	18.7	11.8	27.6
Do......	USDA, 1974	7	19.9	10.4	27.5
Do......	Ref. 0-27, 0-34, 0-39	12	19.4	6.1	30.7
Without skin	USDA, 1977	14	15.2	8.8	23.2
Do......	USDA, 1974	3	6.3	5.6	7.6
Raw whole chicken	USDA, 1974	1	15.4	--	--
Do.......	Ref. 0-24, 0-27, 0-33, 0-34, 0-40	13	19.2	5.0	26.2
Raw whole turkey	USDA, 1974	2	10.4	9.2	11.6
Do.......	Ref. 0-34, 0-41	7	16.6	6.8	19.5
Hand-deboned:					
Cooked fowl meat	USDA, 1977	25	5.3	2.3	8.8
Chicken:					
With skin	USDA, 1973	57	15.0	--	20.6
Without skin	USDA, 1973	28	6.5	--	9.3
Skin	USDA, 1973	28	47.2	--	61.0
Turkey, with skin:					
Small	USDA, 1973	20	4.1	--	6.9
Large	USDA, 1973	19	12.4	--	19.8

Table 33. Content of Essential [1] Amino Acids per Gram of Nitrogen in Mechanically Deboned Poultry, Hand-Deboned Poultry, and Standard Proteins

Product	Isoleucine	Leucine	Lysine	Sulfur-containing: Methionine	Sulfur-containing: Cystine	Aromatic: Phenylalanine	Aromatic: Tyrosine	Threonine	Tryptophan	Valine
	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg
Mechanically deboned poultry:										
Fowl frames, cooked: [2]										
Average	280	490	490	150	70	260	180	200	60	350
Low	[9]260	440	430	40	50	230	160	170	30	300
High	330	540	560	190	90	320	220	240	100	380
Chicken parts, with skin, raw: [3]										
Average	238	502	552	207	[10]N.A.	251	[11]189	220	N.A.	301
Low	221	456	529	166	---	248	---	75	---	259
High	250	556	588	231	---	256	---	306	---	338
Chicken parts, without skin, raw: [3]										
Average	238	517	515	204	N.A.	250	[12]220	277	N.A.	267
Low	225	510	462	175	---	243	215	250	---	256
High	262	525	546	262	---	256	224	296	---	288
Chicken, whole, with or without skin, raw: [4]										
Average	370	500	490	104	N.A.	245	[11]206	200	[13]52	311
Low	231	412	338	12	---	206	---	138	38	219
High	494	556	594	194	---	294	---	294	62	438
Turkey, raw: [5]										
Average	266	489	530	153	N.A.	249	220	276	[14]64	282
Low	236	462	497	103	---	232	167	227	58	256
High	304	523	551	180	---	260	290	304	71	312
Hand-deboned poultry:										
Fowl meat, cooked: [2]										
Average	320	520	520	180	70	260	210	200	70	350
Low	280	480	480	60	60	240	180	180	40	320
High	360	580	580	230	90	300	230	220	120	400
Chicken, muscle without skin: [6]										
Average	330	452	549	163	84	246	220	266	76	307
Low	268	434	469	134	78	232	216	238	58	285
High	356	469	622	195	89	258	223	293	94	336
Turkey, muscle without skin: [6]										
Average	328	478	566	173	86	250	N.A.	264	N.A.	309
Low	311	456	527	168	79	233	---	216	---	290
High	346	500	603	184	94	274	---	294	---	331
Standard proteins:										
Casein [7]	386	621	506	191	27	337	360	266	87	450
Chemical scoring pattern [8]	262	438	319	[15]163		[16]456		219	69	300

1/ Cystine and tyrosine, while not essential, are included because of their close metabolic relationships to methionine and phenylalanine respectively.
2/ Data from USDA study. 26 samples.
3/ Source of data: references P-11 and P-12. 3 samples.
4/ Source of data: references P-11, P-12, and P-13. 7 samples.
5/ Source of data: references P-11 and P-14. 9 samples.
6/ Source of data: reference P-1
7/ Source of data: reference P-16.
8/ Proposed standard pattern of Williams et al. (reference P-3).
9/ One value of 30 mg 1 g of nitrogen omitted.
10/ N.A. means not analyzed.
11/ Value for one sample only.
12/ 2 samples.
13/ 4 samples.
14/ 6 samples.
15/ Methionine plus cystine.
16/ Phenylalanine plus tyrosine.

Table 34. Content of Non-Essential Amino Acids per Gram of Nitrogen in Mechanically Deboned Poultry and Hand-Deboned Poultry

Product	Alanine	Arginine	Aspartic Acid	Glutamic Acid	Glycine	Histidine	Hydroxy-proline	Proline	Serine
	mg	mg	mg	mg	mg	mg	mg	mg	mg
Mechanically deboned poultry:									
Fowl frames, cooked: 1/									
Average	390	470	530	850	500	210	6/ 270	360	240
Low	350	390	460	740	440	170	70	300	210
High	450	540	580	960	600	250	400	430	280
Chicken parts, with skin, raw: 2/	436	431	639	997	495	175	7/ N.A.	334	294
Chicken parts, without skin, raw: 3/									
Average	426	416	646	1034	422	164	N.A.	324	304
Low	424	407	634	1019	402	163	---	321	301
High	429	424	658	1049	443	165	---	328	308
Fowl, whole 2/	407	423	677	1036	367	223	N.A.	283	304
Turkey, raw: 4/									
Average	387	366	595	969	363	177	8/ 78	288	256
Low	356	260	550	900	346	102	71	269	180
High	420	422	649	1049	372	237	87	317	300
Hand-deboned poultry:									
Fowl meat, cooked: 1/									
Average	370	430	510	840	320	250	9/ 90	250	230
Low	320	360	460	790	280	190	70	210	210
High	470	480	560	920	360	290	120	320	260
Chicken, muscle without skin; 5/									
Average	N.A.	395	614	1004	418	180	N.A.	N.A.	N.A.
Low	---	370	606	971	407	137	---	---	---
High	---	441	622	1036	429	233	---	---	---
Turkey, muscle without skin: 5/									
Average	N.A.	394	632	1112	338	169	N.A.	N.A.	N.A.
Low	---	361	629	1102	328	135	---	---	---
High	---	442	636	1123	347	241	---	---	---

1/ Data from USDA study. 26 samples.

2/ Source of data: reference P-11. One sample.

3/ Source of data: reference P-11. 2 samples.

4/ Source of data: reference P-11 and P-14. 9 samples.

5/ Source of data: reference P-15.

6/ 23 samples.

7/ N.A. means not analyzed.

8/ 5 samples.

9/ 9 samples.

Table 35. Protein Quality of Mechanically Deboned Poultry, Hand-Deboned Poultry, and Standard Proteins

Product	Protein Efficiency Ratio (PER)				Essential Amino Acids	
	Rat Growth Assay	Calculated by Equation 1/			In Terms of Protein	In Terms of Total Amino Acids
		1	2	3		
					%	%
Mechanically deboned poultry:						
Fowl frames, cooked: 2/						
Average	2.67 (26)	2.61	2.78	3.33	35.4 (26)	35.0(26)
Low	2.03	2.24	2.42	2.45	28.7	32.3
High	3.23	3.00	3.14	3.81	39.7	36.9
Chicken racks, cooked	3/ 2.57 (7)	---	---	---	---	---
Chicken, cooked	4/ ' 61 (1)	---	---	---	---	---
Chicken racks, raw	3/ 2.47 (7)	---	---	---	---	---
Chicken, raw, whole	4/ 3.01 (1)	---	---	---	6/,8/ 34.4 (2)	5/,8/ 36.4 (4)
Chicken, raw, with skin	6/ 3.10 (1)	---	---	---	6/,7/ 36.4 (3)	5/,8/ 35.2 (4)
Chicken, raw, without skin	6/ 3.04 (2)	---	---	---	6/,7/ 37.0 (4)	5/,8/ 36.0 (8)
Turkey, cooked	4/ 2.77 (1)	---	---	---	---	---
Turkey, raw	---	---	---	---	9/ 36.5 (6)	5/ 36.8 (12)
Hand-deboned poultry:						
Fowl meat, cooked: 2/						
Average	2.92 (25)	2.93	2.98	3.66	37.6 (25)	39.7 (25)
Low	2.66	2.64	2.72	2.69	34.0	38.2
High	3.12	3.27	3.37	4.30	42.0	40.9
Chicken meat, cooked	4/ 3.00 (1)	---	---	---	---	---
Chicken meat, raw without skin	4/ 3.13 (1)	---	---	---	11/,12/ 38.2 (6)	
Turkey, cooked	4/,10/ 3.16 (9)	---	---	---	---	---
Turkey, raw, without skin	10/ 3.40 (2)	---	---	---	8/,11/ 37.9 (4)	---

1/ See reference P-5.

2/ USDA study. Number of samples in parentheses.

3/ Source of data: reference P-6. 7 samples. Racks with legs, breast meat, and wings removed. Data recalculated to a standard of 2.50 for 5:1 casein-lactalbumin.

4/ Source of data: reference P-4.

5/ Source of data: reference P-11.

6/ Source of data: reference P-12.

7/ Source of data: reference P-13.

8/ Tryptophan not included.

9/ Source of data: reference P-14.

10/ Source of data: reference P-17.

11/ Source of data: reference P-15.

12/ 37.0% excluding tryptophan.

Table 36. Protein Content of Mechanically Deboned Poultry and Hand-Deboned Poultry

Product	Source of Data	Samples	Protein Content Average	Low	High
		no.	%	%	%
Mechanically deboned poultry:					
Fowl frames, cooked	USDA, 1977 1/	26	16.5	13.7	19.3
Fowl frames, cooked	Ref P-18	2	16.6	16.4	16.8
Chicken frames, raw	USDA, 1974 2/	1	12.5	---	---
Do........	Ref P-6, P-14, P-18, and P-19	7	13.7	10.5	16.5
Chicken frames, cooked	Ref P-6 and P-14	4	15.8	9.9	18.6
Turkey frames, raw	USDA, 1974	7	14.8	13.3	17.0
Do........	Ref P-14, P-20, P-21, P-22, P-23, P-24, P-25, and P-26	28	14.1	11.7	16.2
Chicken parts, raw:					
With skin	USDA, 1977	20	12.3	10.5	15.4
Do........	USDA, 1974	6	12.5	10.6	14.6
Do........	Ref P-11, P-14, P-18, P-19, P-22, P-23, P-26, P-27, P-28, and P-29	87	11.5	9.3	14.7
Without skin	USDA, 1977	11	14.4	12.4	16.6
	USDA, 1974	3	14.3	13.2	15.8
	Ref P-10, P-13, P-18, P-19, P-22, P-27, P-28, and P-29	52	13.2	11.5	15.6
Turkey parts, raw:					
With skin	USDA, 1977	15	14.7	12.5	17.6
Do........	USDA, 1974	3	13.7	13.4	14.1
Do........	Ref P-11, P-18, P-22	12	14.0	12.1	18.4
Without skin	USDA, 1977	14	15.2	12.3	23.3
Do........	USDA, 1974	5	18.0	17.1	19.1
Do........	Ref P-18 and P-22	2	15.8	15.3	16.4
Chicken, whole, raw	USDA, 1974 2/	2	16.5	15.6	17.7
Do........	Ref P-11, P-14, P-18, P-22, P-23, P-30, P-31	14	15.7	14.0	18.9
Turkey, whole, raw	USDA, 1974	2	19.2	18.6	19.8
Do........	Ref P-18, P-22, and P-32	4	15.6	13.4	17.5
Turkey, cooked	Ref P-18	1	22.01	---	---
Hand-deboned poultry:					
Fowl meat, cooked	USDA, 1977	26	28.8	26.4	30.7
Chicken, flesh and skin:					
Raw	Ref P-33	---	---	15.5	21.6
Cooked	Do........	---	---	26.1	32.6
Chicken, flesh only:					
Raw	Ref P-33	---	---	18.1	23.4
Cooked	Do........	---	---	23.8	32.3
Turkey, flesh and skin:					
Raw	Ref P-33	---	---	19.8	21.6
Cooked	Do........	---	31.9	---	---
Turkey, flesh only:					
Raw	Ref P-33	---	---	20.6	24.7
Cooked	Do........	---	---	30.0	32.9

1/ Analyses made especially for this health and safety evaluation.
2/ Analyses made in anticipation of issuing a product standard.

Table 37. Purine Content of Mechanically Deboned Poultry and Hand-Deboned Poultry

Poultry Product	Xanthine	Hypoxanthine	Guanine	Adenine	Total Purines	Samples
	mg/100g	mg/100g	mg/100g	mg/100g	mg/100g	no.
Mechanically deboned poultry (MDP):						
Raw fowl frames 1/	38.56	21.46	21.12	18.00	99.14	1
Cooked fowl frames 2/	3/	20.06±7.1 4/	16.43±1.4	14.05±2.7	---	3
Raw broiler parts 1/ 2/	43.96±10.8	23.74±8.1	23.30±2.7	19.64±3.9	110.64	4
Raw turkey frames 1/	28.9	24.10	13.44	11.70	78.14	1
Raw turkey parts 2/	52.82±39.7	27.34±12.7	17.56±4.1	15.46±5.0	113.18	5/ 3
All Forms of MDP	41.06±18.28	23.34±7.98	18.37±4.19	15.77±4.21	98.54	12
Analytical Variation 6/	± 2.84	±1.40	± .94	±1.45		
Hand-deboned poultry (HDP):						
Broiler 1/	21.78	52.82	16.10	14.69	105.39	1
Turkey 1/	20.92	49.01	13.76	13.04	96.73	1
All forms of HDP	21.35± .62	50.92±7.69	14.93±1.65	13.87±1.58	101.07	2
Analytical Variation 6/	±1.31	±2.28	±1.28	±1.91		
Muscle: 7/						
Chicken					111	
Turkey					108	
Beef					129	

1/ Source of data: reference Q-3.
2/ Source of data: reference Q-2.
3/ Data not available.
4/ Standard deviation.
5/ Two samples for xanthine.
6/ Each sample was analyzed at least in triplicate; some samples had six replications. The standard deviations presented here represent purely an analytical variability, and not a difference between samples.
7/ Source of data: reference Q-4.

Table 38. Frequency Distribution of Indicator Organisms in Coarsely Ground Starting Material and in Mechanically Deboned Poultry (MDP) 1/

Microorganisms per gram	Coliforms Starting Material	Coliforms MDP	*E. coli* Starting Material	*E. coli* MDP	*S. aureus* Starting Material	*S. aureus* MDP
no.	%	%	%	%	%	%
< 10	0	0	7.6	7.4	17	19
10^1-10^2	31	12	45	37	30	31
$> 10^2$-10^3	47	54	38	46	37	27
$> 10^3$-10^4	20	30	9	9	14	20
$> 10^4$-10^5	2	4	.4	.6	2	3

1/ Distributions are calculated as percentages of 228 production line units of starting material (ground poultry bones with adhering meat or adhering meat and skin) and 298 units of MDP, obtained from 17 establishments. Sampled materials included frames or necks and backs from chicken and turkeys.

Table 39. Aerobic Plate Counts (APC) for Coarsely-Ground Starting Material and Mechanically Deboned Poultry (MDP) Incubated at 35°C and 20°C 1/

Establishment	Poultry Species	Total Units/Total Sets 2/		Geometric Means for APC, Counts Per Gram 3/			
				Incubated at 35°C		Incubated at 20°C	
		Starting Material	MDP	Starting Material	MDP	Starting Material	MDP
		no.	no.	no. x 1000	no. x 1000	no. x 1000	no. x 1000
A	Chicken	2/1	4/1	53	90	ND 4/	ND
B	Chicken	40/4	50/5	31-77	30-230	36-110	ND
C	Chicken	10/1	26/3	320	120-350	340	120-350
D	Chicken	5/	20/2	-	180-9,000	-	160-13,000
E	Turkey	10/1	20/1	180	200	180	190
F	Chicken	30/2	34/2	67-87	110-130	64-69	99-130
G	Turkey	20/2	20/2	15-27	23-30	18-21	27-37
H	Turkey	20/2	20/2	7-20	18-27	7.4-23	16-30
I	Turkey	10/1	10/1	140	180	140	200
J	Turkey	10/1	10/1	24	36	39	50
K	Turkey	20/1	20/1	48	67	72	100
L	Chicken	8/1	8/1	270	290	450	690
M	Chicken	10/1	10/1	330	540	470	760
N	Chicken	10/1	10/1	87	140	95	160
O	Chicken	10/1	10/1	3,200	2,900	6,100	4,700
P	Chicken	10/1	10/1	980	1,700	1,200	2,500
Q	Chicken	8/1	16/1	330	630	310	870

1/ Coarsely-ground starting material (ground poultry bones with adhering meat or adhering meat and skin) and MDP were prepared from frames or necks and backs from chicken and turkey.

2/ A set consists of a number of units, usually 10, which were collected at 30-minute intervals from a pregrinder or mechanical deboner during one production day.

3/ Geometric means of units within a set were calculated for each set. When more than one set was collected at an establishment, the range of geometric means for those sets is given.

4/ ND = not determined.

5/ Establishment D used a closed system which did not allow sampling of coarsely-ground starting material.

Table 40. Frequency of Occurrence of Salmonellae in Coarsely Ground Starting Material and in Mechanically Deboned Poultry (MDP) 1/

Establishment	Species	Coarsely Ground Starting Material Salmonellae-Positive Units/Total Units		MDP Salmonellae-Positive Units/Total Units	
		no.	%	no.	%
A	Chicken	0/2	0	1/4	25
B	Chicken	21/30	70	19/30	63
B 2/	Chicken	10/10	100	20/20	100
C	Chicken	7/10	70	18/26	69
D	Chicken	3/	-	15/20	75
E	Turkey	4/10	40	14/20	70
F	Chicken	8/10	80	9/10	90
F 2/	Chicken	6/20	30	7/24	29
G	Turkey	5/10	50	7/10	70
G 2/	Turkey	1/10	10	5/10	50
H	Turkey	1/10	10	0/10	0
H 2/	Turkey	1/10	10	0/10	0
I	Turkey	0/10	0	0/10	0
J	Turkey	0/10	0	0/10	0
K	Turkey	2/20	10	1/20	5
L	Chicken	0/8	0	0/8	0
M	Chicken	3/10	30	4/10	40
N	Chicken	0/10	0	0/10	0
O	Chicken	2/10	20	0/10	0
P	Chicken	7/10	70	8/10	80
Q	Chicken	5/8	62	14/16	88
All Samples	-	83/228	36	142/298	48

1/ Coarsely ground starting material (ground poultry bones with adhering meat or adhering meat and skin) and MDP were prepared from frames or necks and backs from chicken and turkey.

2/ Units were collected during a different time period from other units reported for this establishment.

3/ Establishment D used a closed system which did not allow sampling of coarsely ground starting material.

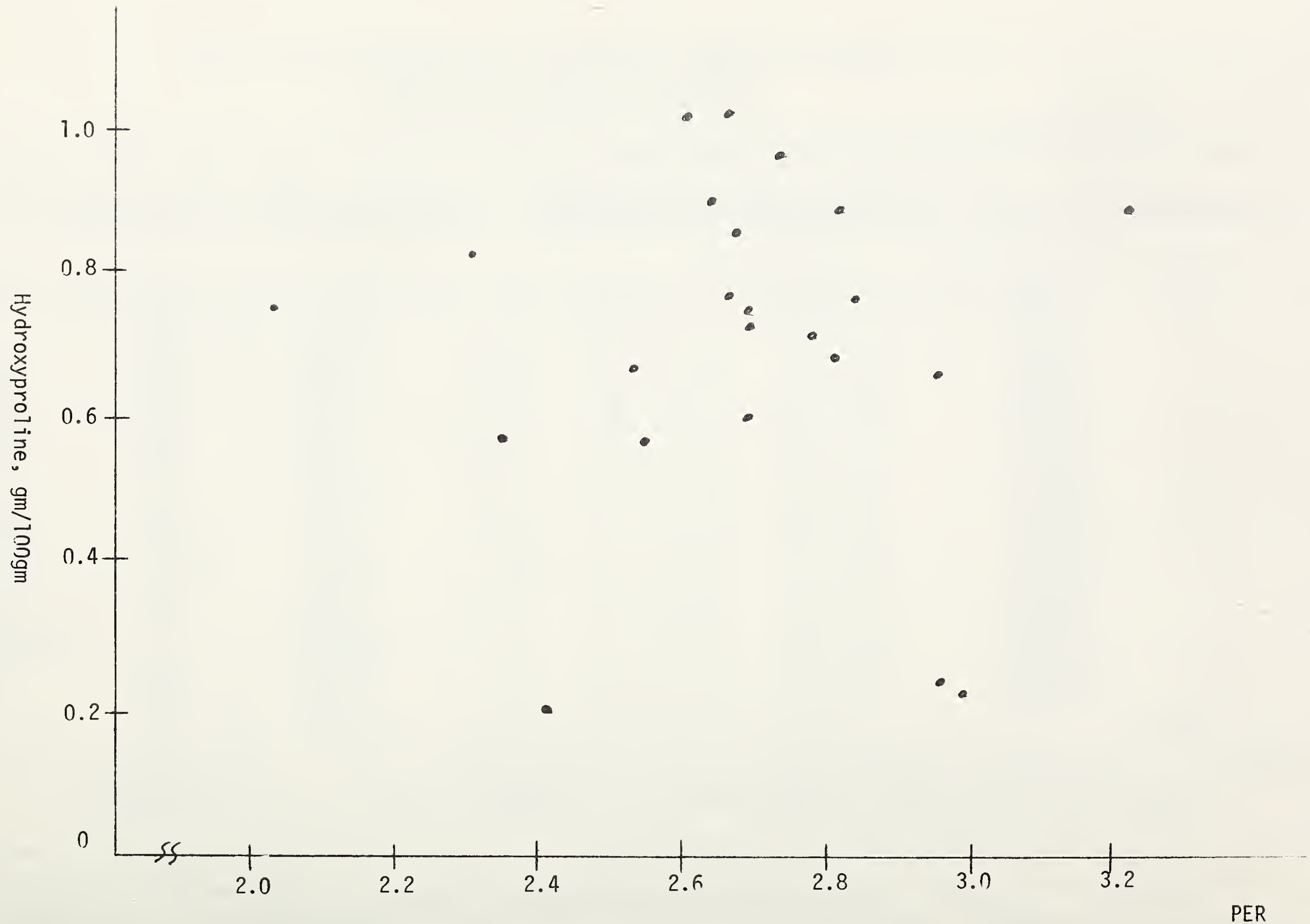

Figure 1. Protein Efficiency Ratio (Bioassay) vs Hydroxyproline content for Mechanically Deboned Poultry.

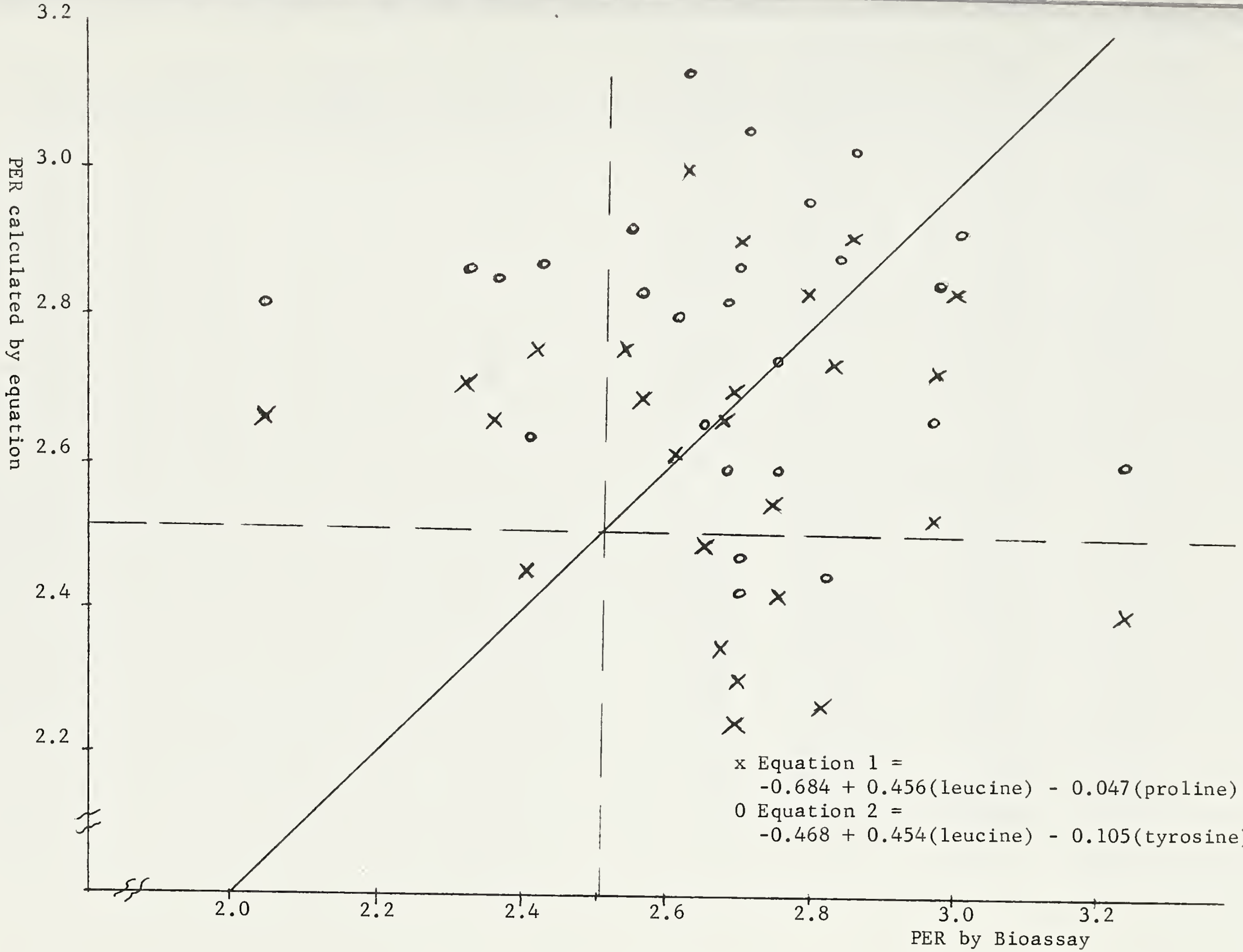

Figure 2. Protein Efficiency Ratio (bioassay) vs PER as calculated from equations for Mechanically Deboned Poultry.

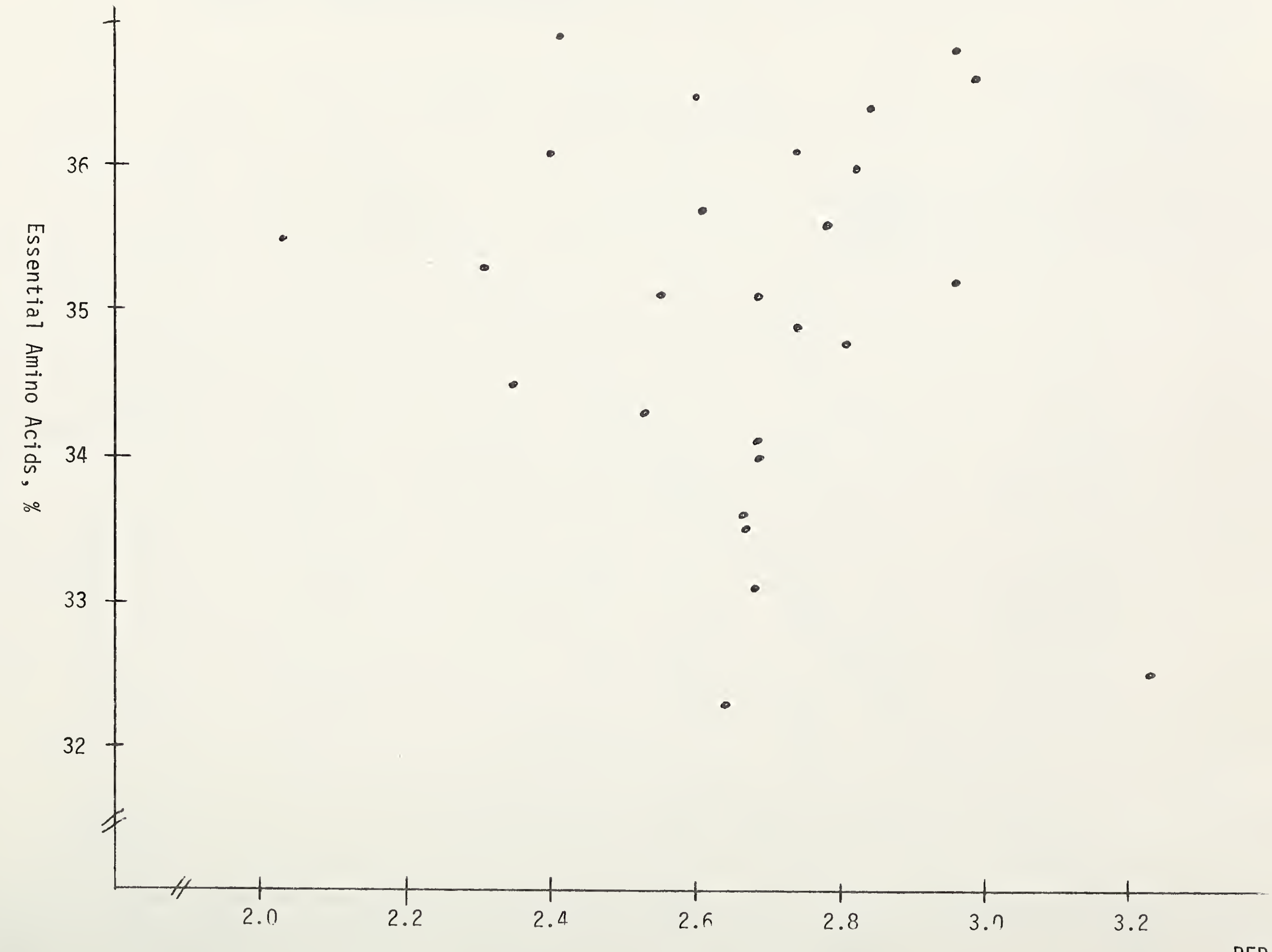

Figure 3. Protein Efficiency Ratio (Bioassay) vs Essential Amino Acids (as percentage of total amino acids) for Mechanically Deboned Poultry

Part V. References

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Bone Particle Size:

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R-2 Brant, A. W., and Guion, C. W. (1972). Microbiology of commercial turkey deboning. Poultry Sci. 51:423-427.

R-3 Peabody, F. R. (1963). Microbial indexes of food quality: the coliform group. In Microbiological Quality of Foods. Slanetz, L. W., Chichester, C. O., Gaufin, A. R., and Ordal, S. J. (eds.). pp. 113-118. Academic Press, New York and London. 274 pp.

R-4 Maxcy, R. B., Froning, G. W., and Hartung, T. E. (1973). Microbial quality of ground poultry meat. Poultry Sci. 52:486-491.

R-5 Guthertz, L. S., Fruin, J. T., and Fowler, J. L. (1977). Microbial flora of preseasoned comminuted turkey meat. J. Food Prot. 40:322-324.

R-6 Guthertz, L. S., Fruin, J. T., Okoluk, R. L., and Fowler, J. L., (1977). Microbial quality of frozen comminuted turkey meat. J. Food Sci. 42:1344.

R-7 Code of Federal Regulations. Title 9, Chapter III, Subchapter C, Mandatory Poultry Products Inspection. Section 381, Poultry Products Inspection Regulations, Paragraph 381.150. Cooking temperature requirements for poultry rolls and certain other poultry products.

Part VI Persons Contributing to this Report

This report was compiled by Elizabeth W. Murphy and Barbara Wells Willis of the Food Ingredient Assessment Division, Science Program, Food Safety and Quality Service, and C. Ronald Brewington of the Meat and Poultry Labeling and Standards Division, Compliance Program, Food Safety and Quality Service.

The conclusions reported are those developed by FSQS officials after careful consideration of the views expressed by members of the Select Panel of Health and Safety Aspects of the Use of Mechanically Deboned Meat (see following section A) and other recognized experts (section B). In addition, FSQS is indebted to many others (section C), who provided services or information.

SECTION A. MEMBERS OF THE SELECT PANEL ON HEALTH AND SAFETY ASPECTS OF THE USE OF MECHANICALLY DEBONED MEAT WHO REVIEWED THIS REPORT ON POULTRY.

1. Joginder Chopra, M.D., Food and Drug Administration; general review.

2. Gerald Combs, Ph.D., National Institute of Arthritis, Metabolism, and Digestive Diseases, National Institutes of Health; general review.

3. Ronald E. Engel, D.V.M., Ph.D., Science Program, Food Safety and Quality Service, U.S. Department of Agriculture; strontium-90; oversight of USDA program for laboratory analyses.

4. Irwin Fried, Compliance Program, Food Safety and Quality Service, U.S. Department of Agriculture; oversight on preparation of this report; general review.

5. M. R. Spivey Fox, Ph.D., Food and Drug Administration; general review; special assistance on cadmium and nickel.

6. Joseph Judd, Ph.D., Nutrition Institute, Science and Education Administration, USDA; general review; special assistance on cholesterol.

7. Albert Kolbye, M.D., J.D., Food and Drug Administration; guidance in planning of this research and evaluation; general review.

8. Eugene Morris, Ph.D., Nutrition Institute, Science and Education Administration, USDA; general review; special assistance on iron.

9. Joseph Naghski, Ph.D., Eastern Regional Research Center, Science and Education Administration, USDA (retired); general review; special assistance on protein and amino acids.

10. M. A. Nelson, D.V.M., Meat and Poultry Inspection Program, Food Safety and Quality Service; Chairman of Task Force preparing this report; general review.

11. Samuel Shibko, M.D., Food and Drug Administration; general review; special assistance on arsenic, cadmium, and lead.

12. Herta Spencer, M.D., Veterans Administration; general review; special assistance on calcium and fluoride.

SECTION B. OTHER PERSONS PROVIDING ASSISTANCE AND INFORMATION

1. <u>Arsenic</u> - John Spaulding, D.V.M., and Zdenka Horakova, Ph.D., Food Safety and Quality Service.

2. <u>Bone particle size</u> - Delvin Zinter, D.V.M., Food Safety and Quality Service; Glen W. Froning, Ph.D., University of Nebraska.

3. <u>Bone particle hardness</u> - John J. Hefferren, Ph.D, American Dental Association Health Foundation.

4. <u>Cadmium</u> - Zdenka Horakova, Ph.D., Food Safety and Quality Service; Kirk Biddle, Ph.D., Food and Drug Administration.

5. <u>Fluoride</u> - Leon Singer, Ph.D., University of Minnesota; W. J. Mueller, D. Sc., Pennsylvania State University.

6. <u>Selenium</u> - Orville Levander, Ph.D., Nutrition Institute, Science and Education Administration, USDA.

7. <u>Strontium-90</u> - Victor Randecker, Food Safety and Quality Service; M. R. Bennink, Ph.D., and A. E. Reynolds, Ph.D., Michigan State University.

8. <u>Nickel</u> - Forrest Nielsen, Ph.D., Human Nutrition Laboratory, Science and Education Administration, USDA.

9. <u>Chlorinated hydrocarbons</u> - John Spaulding, D.V.M., and W. F. Leese, D.V.M., Food Safety and Quality Service; W. J. Stadelman, Ph.D., Purdue University.

10. Cholesterol - Peter O. Kwiterovich, Jr., M.D., and Katherine M. Salz, R.D., John Hopkins University School of Medicine; H. R. Ball, Jr., Ph.D., North Carolina State University.

11. Fatty Acids - Linda Posati, Consumer and Food Economics Institute, Science and Education Administration, USDA.

12. Purines - William C. Weir, Ph.D., and Andrew J. Clifford, Ph.D., University of California-Davis.

13. Microbiology - Douglas F. Campbell, Stanley Green, Ph.D., and Ralph W. Johnston, Food Safety and Quality Service.

SECTION C. PERSONS AIDING IN THE DEVELOPMENT OF ANALYTICAL DATA

1. Food Safety and Quality Service

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2. Other Government Agencies

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J. H. Harley, Health and Safety Laboratory, Energy Research and Development Administration.

Fred Shank, Ph.D., Food and Drug Administration.

Dace Osis and Emilie Wiatrowski, Veterans Administration.

3. Poultry Industry

Julius Bauermann, Ph.D., Horace W. Longacre, Inc., Franconia, Pennsylvania; Chairman, Special Poultry Research Committee. The Committee undertook an extensive program of laboratory analyses to augment the data generated by USDA.

Allen Matthys, Ph.D., National Food Processors Association, Washington, D.C.

Robert Yarem and J. G. Wiegand, Protein Foods Corp., Ltd., Gainesville, Georgia.

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Michigan State University - M. R. Bennink, Ph.D.

University of Nebraska - G. W. Froning, Ph.D.

Pennsylvania State University - J. H. MacNeil, Ph.D.

Utah State University - D. G. Hendricks, Ph.D., A. W. Mahoney., Ph.D., and V. T. Mendenhall, Ph.D.

Virginia Polytechnic Institute and State University - E. O. Essary, Ph.D.

Appendix I

Selection of Samples of Mechanically Deboned Poultry and of Poultry Kidneys

SELECTION OF SAMPLES OF MECHANICALLY DEBONED POULTRY AND OF POULTRY KIDNEYS

Plans for selection of samples were made with the aim of obtaining data that would be reasonably representative of mechanically deboned poultry (MDP) as produced on a nationwide basis. Each regional office of FSQS's Meat and Poultry Inspection Program, Field Operations, prepared a list of all establishments in its region which were currently producing MDP, the type of MDP (young chicken, turkey, or fowl) produced, and the amount of production. From these lists, establishments were chosen from which to collect samples. Selection was random, with probability of selection being equal to that establishment's production as a proportion of total production. Selections were made separately for cooked fowl frames, young chicken parts, and young turkey parts.

Hand-deboned cooked fowl meat was taken from the same production lot as mechanically deboned cooked fowl meat, and contained little or no skin, as indicated by values for fat in Appendix Table III-1.

For young chicken and turkey parts, there was no attempt to further stratify the sample by prior selection of establishments producing MDP with or without skin. Instead, establishments to provide samples were selected as described in the preceding paragraph, and samples subsequently collected were identified as to whether or not they contained skin. The numbers of samples with

and without skin were: for young chicken, 20 and 12 respectively; for young turkey, 15 and 14 respectively. The final sample is thus representative of nationwide production at the time of sampling of MDP from young chicken and young turkey.

For selection of samples of kidneys from fowl and young chicken, the file used for the regular scheduling of residue evaluation provided the list of eligible establishments. Establishments were randomly selected, with the probability of selection being equal to the establishment's slaughter rate. Inspectors were instructed to randomly select a lot of birds and to collect kidneys from 10 birds in this lot.

Data for kidneys did not follow normal distribution. Evaluations indicated that the geometric mean was the best approximation of median (50th percentile) levels, and that the lognormal distribution was the most suitable approximation of the 90th percentile value. These were the values used in subsequent evaluations on effects of cadmium and lead in poultry kidneys on safety of use of MDP.

Appendix II

Methods Used in Analyzing Mechanically Deboned Poultry

Appendix Table II-1. Summary of the Methods of Analysis for Mechanically Deboned Poultry (MDP) and Hand Deboned Poultry (HDP):

Cooked Fowl Frames

Test	Primary Laboratory	Method Reference	Verification Laboratory	Method Reference
Protein	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Wash, DC.	Official Methods of Analysis (1975). AOAC Procedure 24.024, 12th Ed. Wash, DC.	Technological Resources, Inc. Camden, NJ.	Same as primary lab.
Fat	"	AOAC Procedure 24.005, 12th Ed. (1975).	"	"
Ash	"	AOAC Procedure 31.013 12th Ed. (1975).	"	"
Moisture	"	AOAC Procedure 24.003 12th Ed. (1975).	"	"
Arsenic	Western Multidisciplinary Lab., FSQS, USDA. San Francisco, CA.	USDA Chemistry Laboratory Guidebook, Method 5.010 (1979).	Eastern Multidisciplinary Lab., FSQS, USDA. Athens, GA.	"
Bone Sizing	Pathology Lab., FSQS, USDA. Beltsville, MD.	Unpublished Microscopic Methods. 1/	None	None
Percentage Bone	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Wash, DC.	USDA Chemistry Laboratory Guidebook, Method 6.009 (1979).	None	None
Cadmium	Chemistry Lab., FSQS, USDA. Omaha, NE.	Modified AOAC Procedure 25.065, 12th Ed. (1975).	Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Beltsville, MD.	Same as primary lab
Calcium	"	USDA Chemistry Laboratory Guidebook, Method 6.007 (1979).	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Wash, DC.	USDA-Chemistry Laboratory Guidebook, Method 6.009 (1979).

(Appendix Table II-1, cont.)

Test	Primary Laboratory	Method Reference	Verification Laboratory	Method Reference
Iron	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Wash, DC.	USDA Chemistry Laboratory Guidebook, Method 6.008 (1979).	Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Beltsville, MD.	Andreasen, C. A., and Vasco, G. A. Determination of Cadmium, Cobalt, Copper, Iron, Manganese, Nickel, and Zinc on Animal Tissue by Atomic Absorption Spectroscopy (Unpublished). 1/
Nickel	Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Beltsville, MD.	Andreasen, C. A. and Vasco, G. A. Determination of Cadmium, Cobalt, Copper, Iron, Manganese, Nickel, and Zinc on Animal Tissue by Atomic Absorption Spectroscopy (Unpublished). 1/	Chemistry Lab., FSQS, USDA. Omaha, NE.	Same as primary lab.
Zinc	"	"	"	"
Chlorinated Hydrocarbons	Chemistry Division Lab. Special Projects Unit, FSQS, USDA. Wash, DC.	USDA Chemistry Laboratory Guidebook, Method 5.001 (1979).	Eastern Multidisciplinary Lab., FSQS, USDA. Athens, GA.	"
Cholesterol	Chemistry Lab., FSQS, USDA. Kansas City, KS.	FDA Interim Methodology Instructions #2 for Fat, Fatty Acids, & Cholesterol.	Technological Resources, Inc., Camden, NJ.	"
Fatty Acids	"	"	"	"
Total Lipids	"	"	"	"
Amino Acid Profile	Technological Resources, Inc. Camden, NJ.	Modified Moore and Stein Column Chromatography Procedure.	None	None
Tryptophan	Technological Resources, Inc. Camden, NJ.	Lombard, J. H. and D. J. De Lange, Chemical Determination of Tryptophan in Food and Mixed Diets. Anal. Bioch. 10, 260-265 (1965).	None	None

(Appendix Table II-1, cont.)

Test	Primary Laboratory	Method Reference	Verification Laboratory	Method Reference
Calcium (Cont'd)			Health & Safety Lab., ERDA. New York, NY.	Modified AOAC Procedure 2.096, 12th Ed. (1975).
			Western Multidisciplinary Lab., FSQS, USDA. San Francisco, CA.	Same as primary lab. and USDA-Chemistry Laboratory Guidebook, Method 6.0009 (1979).
Phosphorus	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Wash, DC.	USDA Chemistry Laboratory Guidebook, Method 3.006 (1979).	Western Multidisciplinary Lab., FSQS, USDA. San Francisco, CA.	Same as primary lab.
Fluoride	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Wash, DC.	Dolan T. et. al. (1978). Determination of Fluoride in Mechanically Deboned Meat. JAOAC 61 (4): 982-985.	Veterans Administration Hospital. Hines, IL.	Singer, L. and Armstrong, W. D. (1959). Determination of Fluoride in Blood Serum. Analyt. Chem. 31 (1): 105-109.
Lead	Chemistry Lab., FSQS, USDA. Omaha, NE.	Modified AOAC Procedure 25.065, 12th Ed. (1975).	Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Beltsville, MD.	Same as primary lab.
Selenium	Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Beltsville, MD.	Andreasen, C.A. and Vasco, G.A. Determination of Selenium in Animal Tissues (Unpublished). 1/	None	None
Strontium-90	Health & Safety Lab., ERDA. New York, NY.	Health & Safety Lab. Manual for Standard Procedures #300.	None	None
Cobalt	Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Beltsville, MD.	Andreasen, C.A. and Vasco, G. A. Determination of Cadmium, Cobalt, Copper, Iron, Manganese, Nickel, and Zinc in Animal Tissue by Atomic Absorption Spectroscopy (Unpublished). 1/	Chemistry Lab., FSQS, USDA. Omaha, NE.	Same as primary lab.
Copper	"	"	"	"

(Appendix Table II-1, cont.)

Test	Primary Laboratory	Method Reference	Verification Laboratory	Method Reference
PER	Technological Resources, Inc. Camden, NJ.	AOAC Procedure 43.183, 12th Ed. (1975).	None	None
Microbiological Examinations	Food Microbiology Branch, FSQS, USDA, Beltsville, MD.	Unpublished Methods.1/	None	None

1/ Single copies of methods are available on request.

Appendix Table II-2. Summary of the Methods of Analysis for Mechanically Deboned Poultry (MDP):

Raw Chicken and Turkey Parts

Test	Primary Laboratory	Method Reference	Verification Laboratory	Method Reference
Protein	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Washington, DC.	Official Methods of Analysis (1975), AOAC Procedure 24.024, 12th Ed. Washington, DC.	Eastern Multidisciplinary Laboratory, FSQS, USDA. Athens, GA.	Same as primary lab.
Fat	"	AOAC Procedure 24.005, 12th Ed. (1975).	"	Same as primary lab.
Ash	"	AOAC Procedure 31.013, 12th Ed. (1975).	"	Same as primary lab.
Moisture	"	AOAC Procedure 24.003, 12th Ed. (1975).	"	Same as primary lab.
Arsenic	Eastern Multidisciplinary Lab., FSQS, USDA. Athens, GA.	USDA-Chemistry Lab.Guide-book, Method 5.010 (1979).	Chemistry Lab., FSQS, USDA. Omaha, NE.	Same as primary lab.
Bone Sizing	Pathology Lab., FSQS, USDA. Beltsville, MD.	Unpublished Microscopic Methods. 1/	None	None
Cadmium	Chemistry Lab., FSQS, USDA. Omaha, NE.	Modified AOAC Procedure 25.065, 12th Ed. (1975).	(1) Analytical Chemistry and Physics Branch, FDA. Washington, DC.	Jones, J.W.; Gojan, R. J.; Boyer, K. W.; and Fiorino, J. A. (1977). Dry Ash Voltametric Determination of Cadmium, Copper, Lead, and Zinc in Foods. JAOAC 60 (4): 826-832.
			(2) Chemistry Division Lab. Methods Development Unit, FSQS, USDA. Washington, DC.	Modified AOAC Procedure 25.065, 12th Ed. (1975).

(Appendix Table II-2, cont.)

Test	Primary Laboratory	Method Reference	Verification Laboratory	Method Reference
Calcium	Chemistry Division Lab., Special Projects Unit, FSQS, USDA. Washington, DC.	USDA-Chemistry Lab. Guidebook, Method 6.007 (1979).	None	None
Fluoride	"	Dolan, T. et al. (1978). Determination of Fluoride in Mechanically Deboned Meat. JAOAC <u>61</u> (4): 982-985.	Veterans Admin. Hospital. Hines, IL.	Singer, L. and Armstrong, W.D. (1959). Determination of Fluoride in Blood Serum. Analytical Chem. 31 (1): 105-109.
Lead	Chemistry Lab., FSQS, USDA. Omaha, NE.	Modified AOAC Procedure 25.065, 12th Ed. (1975).	(1) Analytical Chemistry and Physics Branch, FDA. Washington, DC.	Jones, J. W., Gojan, R. J., Boyer, K. W., and Fiorino, J. A. (1977). Dry Ash Voltametric Determination of Cadmium, Copper, Lead, and Zinc in Foods. <u>JAOAC</u> 60 (4): 826-832.
			(2) Chemistry Division Lab., Methods Development Unit, FSQS, USDA. Washington, DC.	Same as primary lab.
Chlorinated Hydrocarbons	"	USDA Chemistry Lab. Guidebook, Method 5.001 (1979).	None	None
Cholesterol	Chemistry Lab., FSQS, USDA. Kansas City, KS.	FDA Interim Methodology Instruction #2 for Fat, Fatty Acids, and Cholesterol.	None	None

1/ Single copies of method are available on request.

Appendix III

USDA Analytical Data for Mechanically Deboned Poultry

Appendix Table III-1. Summary of USDA Analytical Data for Mechanically Deboned Poultry (MDP) and Hand Deboned Poultry (HDP): Cooked Fowl Frames

Substance	Sample Size		Average		Standard Deviation		Range Lower		Range Upper		90th Percentile	
	HDP	MDP	HDP	MDP	HDP	MDP	HDP	MDP	HDP	MDP	HDP	MDP
Moisture (%)	25	26	65.8	66.2	1.68	3.65	62.6	59.9	68.3	75.4	68.0	71.0
Protein (%)	25	26	28.8	16.2	1.49	1.76	26.1	13.7	31.0	19.4	30.7	18.5
Fat (%)	25	26	5.3	17.1	1.38	4.03	2.3	6.3	8.8	24.8	7.1	22.4
Ash (%)	25	26	.70	.85	.093	.166	.6	.5	1.0	1.3	.83	1.07
Arsenic (mcg/g)	25	26	< .02	<.02	--	--	<.01	<.01	<.01	<.01	--	--
Cadmium (mcg/g)	25	26	< .01	< .01	--	--	< .01	<.01	0.01	0.02	--	--
Calcium (%)	25	26	.020	.209	.014	.055	.0	.097	.053	.355	.05	.28
Phosphorus (%)	25	26	.16	.17	.019	.024	.14	.13	.22	.23	.18	.20
Fluoride (mcg/g)	25	26	.70	14.38	.28	6.9	.40	3.25	1.88	25.25	1.07	23.51
Lead (mcg/g)	25	26	.02	.05	.027	.053	.0	.0	.08	.22	.06	.12
Selenium (mcg/g)	25	26	.19	.14	.063	.062	.07	.05	.32	.32	.27	.22
Strontium-90 (pCi/kg)	2	8	.4	2.5	.07	1.25	.40	1.0	.5	4.3	--	--
Cobalt (mcg/g)	24	26	.11	.13	.044	.028	.03	.06	.26	.18	.16	.17
Copper (mcg/g)	23	26	.80	.69	.115	.155	.51	.51	1.00	1.13	.95	.89
Iron (mcg/g)	24	24	67.0	43.8	39.5	21.9	15.0	18.0	173.5	91.0	119	83.
Nickel (mcg/g)	21	22	.35	.53	.153	.594	.10	.15	.60	2.84	.55	1.4
Zinc (mcg/g)	24	26	13.8	18.6	2.56	4.81	7.8	12.2	19.6	34.0	17.2	25.0
Cholesterol (mg/100g)	8	8	64	140.5	9.5	19.3	46.	110.	79.	169.	77.	168.

Appendix Table III-2
Summary of USDA Analytical Data for Mechanically Deboned Poultry (MDP):
Raw Chicken Parts

Component	Sample Size		Average		Standard Deviation		Range: Lower		Range: Upper		90th Percentile	
	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin
Moisture (%)	20	12	65.2	69.6	3.6	2.2	58.2	68.2	69.8	72.6	70.0	72.5
Protein (%)	20	12	12.3	14.5	1.3	1.3	10.5	12.4	15.6	16.6	14.0	16.3
Fat (%)	20	12	22.4	15.0	4.2	2.2	15.2	11.6	30.2	18.3	27.9	18.0
Ash (%)	20	12	.87	1.08	.13	.32	.66	.77	1.11	1.90	1.05	1.51
Arsenic (mcg/g)	20	12	.043	.037	.032	.027	$<$.01	$<$.01	.12	.09	.086	.074
Fluoride (mcg/g)	20	12	1.78	2.27	.68	1.05	.9	.9	3.9	3.8	2.68	3.69
Cholesterol(mg/100g)	3	2	130.5	104.6	-	-	119.8	97.1	148.0	112.1	-	-

Cadmium - 31 samples analyzed; 30 had non-detectable levels of cadmium (less than 0.01 mcg/g); one sample contained 0.02 mcg/g.

Lead - 31 samples analyzed; 28 had non-detectable levels of lead (less than 0.01 mcg/g); the other 3 samples contained 0.01, 0.08, and 0.07 mcg/g.

Appendix Table III-3

Summary of USDA Analytical Data for Mechanically Deboned Poultry (MDP): Raw Turkey Parts

Component	Sample Size		Average		Standard Deviation		Range				90th Percentile	
							Lower		Upper			
	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin	With Skin	Without Skin
Moisture (%)	15	14	65.7	69.6	2.6	4.0	61.2	62.6	70.9	77.3	69.2	75.0
Protein (%)	15	14	14.7	15.3	1.4	2.7	12.5	12.3	17.6	23.3	16.7	18.9
Fat (%)	15	14	18.7	15.0	3.9	4.2	11.8	8.8	27.6	23.2	24.0	20.6
Ash (%)	15	14	0.99	0.97	0.16	0.21	0.70	0.45	1.34	1.25	1.22	1.25
Arsenic (mcg/g)	13	13	0.029	0.013	0.026	0.020	<0.01	<0.01	0.06	0.06	0.064	0.040
Fluoride (mcg/g)	15	14	1.81	1.64	0.62	0.70	0.8	0.9	2.8	3.4	2.65	2.59
Cholesterol 1/ (mg/100g)	3	1	95.0	99.8	-	-	85.5	-	105.1	-	-	-

Cadmium - 26 samples analyzed; 24 had non-detectable levels of Cd (less than 0.01 mcg/g); one sample contained 0.01 mcg/g; one sample contained 0.02 mcg/g.

Lead - 26 samples analyzed; all had non-detectable levels of lead (less than 0.01 mcg/g).

1/ One sample analyzed contained 98.7 mg/100g; however, it was not known if the sample was with or without skin.

Appendix Table III-4. Fat Components of Mechanically Deboned Cooked Fowl Frames

Producer		A	B	C	C	D	E	F	A	Avg
Geographic Area		W	SW	NE	NE	SW	SE	W	W	
Total lipid, % of MDP		16.9	6.8	16.7	16.2	19.9	16.3	18.7	14.2	15.7
Total fatty acids, % of total lipid		90.59	89.63	95.44	94.61	93.26	90.34	93.42	96.48	92.97
Fatty acid methyl ester (FAME), % of total FAME:										
C14:0	Myristate	0.9	0.8	0.8	0.7	0.8	0.7	0.8	0.9	0.8
*C14:1	Myristoleate	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2
*C14:X	Unknown	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.2
C16:0	Palmitate	19.1	18.6	17.5	17.6	17.6	16.6	17.4	19.4	18.0
C16:1 (9)	Palmitoleate	4.0	4.9	4.7	4.2	3.9	4.4	4.8	3.4	4.3
*C16:2 (9, 12)	Palmitolenoleate	0.1	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.2
*C17:0	Heptadecanoate	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.4	0.4
*C17:1	Heptadecenoate	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.2
C18:0	Stearate	7.4	5.8	4.9	4.8	5.4	5.5	5.3	7.8	5.9
C18:1 (9)	Oleate	45.9	41.3	43.7	43.6	46.8	47.5	46.5	43.8	44.9
C18:2 (9, 12)	Linoleate	18.9	23.4	24.5	25.2	21.7	21.6	21.4	20.7	22.2
C18:3 (6, 9, 12)	Linolenate	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
C18:3 (9, 12, 15)	Linolenate	1.2	1.2	1.2	1.2	1.5	1.1	1.3	1.2	1.2
C20:2 (11, 14)	Eicosadienoate	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
C20:3 (8, 11,14)	Homo-Linoleate	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
C20:4 (5, 8, 11, 14)	Arachidonate	0.5	0.9	0.5	0.5	0.5	0.4	0.5	0.5	0.5
C20:5 (5, 8, 11, 14, 17)	Eicosapentaenoate	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C22:4 (7, 10, 13, 16)	Docosatetraenoate	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
C22:5 (4, 7, 10, 13, 16)	Docosapentaenoate	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C22:5 (7, 10, 13, 16, 19)	Docosapentaenoate	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C22:6 (4, 7, 10, 13, 16, 19)	Docosahexaenoate	0.1	0.5	<0.1	<0.1	0.1	0.2	0.1	0.2	0.2
C24:0	Lignocerate	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Cholesterol, mg./100 g total lipids		945	1835	890	680	850	780	760	1000	96.8

1/ Data as analyzed. See text tables for data calculated by normalizing equations.
* Identified from plot of log of retention time vs. carbon chain length.

Appendix Table III-5. Summary of USDA Analytical Data for Essential 1/ Amino Acids in Mechanically Deboned Cooked Fowl Frames and Hand-Deboned Cooked Fowl Meat

		Essential Amino Acids Per Gram of Total Nitrogen									
					Sulfur-Containing		Aromatic				
Processor	Samples no.	Iso-leucine mg	Leucine mg	Lysine mg	Meth-ionine mg	Cystine mg	Phenyl-alanine mg	Tyrosine mg	Threo-nine mg	Trypto-phan mg	Valine mg
Mechanically deboned cooked fowl frames:											
A	7	0.26	0.50	0.48	0.17	0.07	0.26	0.18	0.20	0.06	0.34
B	2	.32	.52	.52	.18	.08	.27	.20	.21	.05	.35
C	8	.28	.48	.49	.15	.07	.27	.18	.19	.06	.35
D	2 2/	.31	.51	.53	.17	.08	.28	.21	.20	.10	.36
E	2	.28	.48	.48	.16	.07	.25	.17	.19	.04	.35
F	5	.28	.48	.47	.12	.07	.25	.18	.19	.06	.33
Weighted average	26	.28	.49	.49	.15	.07	.26	.18	.20	.06	.35
Hand-deboned cooked fowl meat:											
A	7	.32	.53	.52	.19	.07	.27	.21	.20	.08	.36
B	2	.32	.53	.53	.19	.07	.26	.21	.20	.07	.36
C	8	.33	.52	.52	.19	.07	.27	.21	.20	.07	.35
D	2	.33	.52	.54	.20	.07	.27	.21	.19	.06	.36
E	1	.32	.52	.49	.17	.08	.26	.20	.20	.05	.34
F	5	.30	.50	.49	.12	.07	.25	.20	.19	.05	.34
Weighted average	25	.32	.52	.52	.18	.07	.26	.21	.20	.07	.35

1/ Cystine and tyrosine, while not essential, are included in this table because of their close metabolic relationships to methionine and phenylalanine respectively.

2/ One sample for tryptophan.

Appendix Table III-6. Summary of USDA Analytical Data for Non-Essential Amino Acids 1/ and Protein Efficiency Ratios in Mechanically Deboned Cooked Fowl Frames and Hand-Deboned Cooked Fowl Meat

Processor	Samples	Non-Essential Amino Acids Per Gram of Total Nitrogen									PER
		Alanine	Arginine	Aspartic acid	Glutamic acid	Glycine	Histidine	Hydroxy-proline	Proline	Serine	
	no.	mg	mg	mg	mg	mg	mg	mg	mg	mg	
Mechanically deboned cooked fowl frames:											
A	7	0.39	0.47	0.52	0.83	0.49	0.21	0.27	0.35	0.24	2.44
B	2	.40	.48	.54	.90	.44	.18	.28	.36	.24	2.83
C	8 2/	.40	.48	.54	.86	.53	.22	.30	.37	.24	2.65
D	2	.40	.50	.55	.91	.46	.23	.09	.35	.24	2.97
E	2 3/	.40	.46	.52	.86	.52	.19	-	.36	.24	2.50
F	5	.38	.44	.51	.82	.50	.20	.31	.34	.24	2.89
Weighted average	26 4/	.39	.47	.53	.85	.50	.21	.27	.36	.24	2.67
Hand-deboned cooked fowl meat:											
A	7 5/	.36	.44	.50	.83	.31	.25	.09	.26	.24	2.81
B	2 6/	.36	.45	.53	.87	.32	.25	-	.23	.23	2.82
C	8 7/	.37	.44	.53	.87	.35	.25	.12	.27	.23	2.97
D	2 6/	.42	.44	.52	.87	.33	.26	-	.27	.23	3.01
E	1	.36	.37	.50	.82	.29	.23	.09	.26	.23	3.07
F	5 7/	.34	.39	.47	.78	.29	.25	.08	.23	.22	2.98
Weighted average	25 8/	.37	.43	.51	.84	.32	.25	.09	.25	.23	2.92

1/ Histidine is included in this table, although there is evidence that it is essential for infants.
2/ Seven samples for hydroxyproline.
3/ No analyses for hydroxyproline.
4/ 23 samples for hydroxyproline.
5/ Six samples for hydroxyproline.
6/ No analyses for hydroxyproline.
7/ One sample for hydroxyproline.
8/ Nine samples for hydroxyproline.

Appendix IV

The Special Poultry Research Committee's Analytical Data on Mechanically Deboned Poultry

Appendix Table IV-1. Calcium, Fluoride, and Lead Contents of Mechanically Deboned Poultry: Summary of Data Submitted by the Special Poultry Research Committee

Product	Calcium Content				Fluoride Content				Lead Content			
	Samples	Average	Low	High	Samples	Average	Low	High	Samples	Average	Low	High
	no.	%	%	%	no.	mcg/g	mcg/g	mcg/g	no.	mcg/g	mcg/g	mcg/g
Mechanically Deboned Poultry:												
Chicken (young):												
Frames, raw	23	0.108	0.041	0.229	22	1.49	0.57	2.20	15	0.06	0.01	0.13
Frames, cooked	14	.134	.060	.200	14	1.89	.40	3.10	6	.01	< .01	.01
Parts, raw	43	.120	.036	.317	52	1.51	< .40	3.30	35	.06	< .01	.12
Parts, cooked	5	.055	.042	.070	5	.65	< .40	1.10	3	<.01	< .01	< .01
Chicken (mature):												
Frames, fowl, raw	13	.213	.137	.349	13	10.18	3.72	23.25	6	< .09	.07	.11
Frames, fowl, cooked	30	.265	.158	.487	30	18.1	2.05	43.80	27	.08	.01	.14
Carcass, whole, stag, raw	3	.077	.072	.081	3	1.2	.8	1.5	-			
Carcass, whole, fowl, cooked	3	.212	.188	.226	3	15.2	12.8	17.2	3	< .1	< .1	< .1
Turkey (young):												
Frames, raw	51	.147	.060	.255	50	1.77	< .40	3.30	51	.08	.0	.26
Parts, raw	6	.143	.090	.250	8	2.27	1.02	4.94	4	.09	.04	.24
Hand-deboned poultry:												
Chicken (fowl):												
Light and dark meat plus skin, raw	3	.015	.013	.017	3	.85	.70	.96				
Light and dark meat, cooked	3	.025	.022	.030	3	1.38	.90	1.63	3	.09	.09	.10
Turkey (young):												
Light meat, raw					2	.52	.50	.53				
Dark meat, raw					2	.56	.47	.64				
Meat, cooked	3	.024	.018	.035	3	.95	.85	1.14	3	<.09	< .09	<.09
Whole, raw	3	.009	.008	.010	3	.86	.75	.94				

Appendix Table IV-2. Content of Seven Mineral Elements in Mechanically Deboned Poultry: Summary of Data Submitted by the Special Poultry Research Committee

Mineral Element	Mechanically Deboned Poultry Product	Samples	Average	Low	High
		no.			
Arsenic (mcg/g)	Chicken (young) parts, raw	1	<0.02	-	-
	Chicken (mature) frames, fowl, cooked	5	<0.02	<0.02	<0.02
Cadmium (mcg/g)	Chicken (young) parts raw	1	.02	-	-
	Chicken (mature) frames, fowl, cooked	5	.02	.01	.02
Copper (mcg/g)	Chicken (young) parts, raw	1	.41	-	-
	Chicken (mature) frames, fowl, cooked	5	.54	.17	.77
Iron (mcg/g)	Chicken (young) parts, raw	1	20.1	-	-
	Chicken (mature) frames, fowl, cooked	5	20.8	18.5	23.0
Nickel (mcg/g)	Chicken (young) parts, raw	1	.7	-	-
	Chicken (mature) frames, fowl, cooked	5	.8	.8	.8
Selenium (mcg/g)	Chicken (young) parts, raw	1	.09	-	-
	Chicken (mature) frames, fowl, cooked	5	.08	.04	.12
Strontium-90 (pCi/kg)	Turkey (young) carcass, whole, male, raw	2	3.56	1.22	5.89
	Turkey (young) frames, raw	2	11.93	11.70	12.16
	Turkey (young) parts, raw	1	30.19	-	-

Appendix V

Production of Poultry
in Calendar Year 1976

Appendix Table V-1. Production of Poultry in Calendar Year 1976

Type of Poultry	Ready-to-Cook	Further Processed	
	lb.	lb.	% of Ready-to-Cook
Young chickens	9,008,713,000	647,845,000	7.19
Mature chickens	491,355,000	441,558,000	89.86
Turkeys	1,950,078,000	612,285,000	31.39
*Other	62,590,000	117,610,000	187.90
Total	11,512,736,000	1,819,298,000	15.80
Total excluding other	11,450,146,000	1,701,688,000	14.86

* Undoubtedly includes cold storage.

Appendix VI

Calculations of Cadmium and Lead Contents of Mechanically Deboned Poultry Made from Raw Broiler or Fowl Backs with Kidneys

Appendix Table VI-1. Calculations of Cadmium and Lead Contents of Mechanically Deboned Poultry Made from Raw Broiler or Fowl Backs with Kidneys

Age Group	MDP Harvested from One 250-g Back 1/	Weight of Kidney	Cadmium Content		Lead Content	
			In Kidneys	In MDP 2/	In Kidneys	In MDP 2/
	g	g	mcg/g	mcg/g	mcg/g	mcg/g
Broilers	125	10	3/ 0.05	0.004	3/ 0.07	0.006
	125	10	4/ .11	.009	4/ .16	.013
Fowl	125	15	3/ .80	.096	3/ .06	.007
	125	15	4/ 2.03	.244	4/ .12	.014

1/ Assumes 50 percent yield of MDP and that all of the kidneys are incorporated into the MDP. Yields of MDP from backs are usually 70 percent or higher (C-10). The lower yield was used in these calculations to provide a margin of safety.

2/ Assumes that all cadmium and lead come from the kidneys.

3/ Geometric mean of 100 analyses by USDA.

4/ Upper limit 90th percentile values for 100 analyses made by USDA.

Appendix VII

Daily Per Capita Consumption of Selected Minerals from Mechanically Deboned Poultry

All "further processed" is MDP -- 39.1 x 0.86 + 6.9 x 1.51 = 44.0 mg.

Appendix Table VII-1. Calculations of Contents of Cadmium, Calcium, Fluoride, Lead, and Cholesterol in Poultry, Weighted According to 1976 Production 1/

Type of Poultry	Proportion of 1976 Production	Cadmium Content 2/		Calcium Content 3/		Fluoride Content 4/		Lead Content 5/		Cholesterol Content 6/	
		mcg/g	total mcg	%	total mg	mcg/g	total mcg	mcg/g	total mg	mg/g	total mg
Ready-to-cook, hand-deboned:											
Young chicken	0.79	0.	0.	0.014	0.111	0.9	0.71	(0.02)	0.016	0.89	0.70
Mature chicken	.04	0.	0.	.020	.008	.7	.03	.02	.001	.64	.03
Turkey	.17	0.	0.	.024	.041	.9	.15	(.02)	.003	.79	.13
Weighted value per gram	1.00	-	0.	-	.160	-	.89	-	0.020	-	.86
Further processed, hand-deboned:											
Young chicken	.38	0.	0.	.014	.053	.9	.34	(.02)	.008	.89	.34
Mature chicken	.26	0.	0.	.020	.052	.7	.18	.02	.005	.64	.17
Turkey	.36	0.	0.	.024	.086	.9	.32	(.02)	.007	.79	.28
Weighted value per gram	1.00	-	0.	-	.191	-	.84	-	0.020	-	.79
Further processed, MDP:											
Young chicken	.38	0.	0.	.134	.509	3	1.14	.01	.004	1.71	.65
Mature chicken	.26	0.137	.036	.209	.543	14	3.64	.050	.013	1.40	.36
Turkey	.36	0.	0.	.167	.601	3	1.08	0	0.	1.39	.50
Weighted value per gram	1.00	-	.036	-	.653	-	5.86	-	.017	-	1.51

1/ All calculations are based on amounts of components in cooked poultry. Values for cooked poultry that were calculated from data on the raw form assume a shrinkage with cooking of 30 percent and no loss of the mineral or cholesterol.

2/ Values for cadmium in MDP were taken from Table 4. Values for young chicken and turkey, which were below the level of detectability, have been set at 0. The value for mature chicken is for MDP made from raw fowl backs with kidneys, adjusted for cooking changes.

3/ Values for calcium were obtained as follows: Hand-deboned young chicken meat is the average of light and dark meat, cooked by dry and moist heat, from Table 7; hand-deboned mature chicken and corresponding MDP are values for cooked fowl in Table 6; hand-deboned cooked whole turkey is from Table 7; and turkey MDP is calculated from the values for calcium in raw turkey frames, 0.117 percent, in Table 6.

4/ Fluoride contents of all MDP and of hand-deboned young and mature chicken are from Table 8. For hand-deboned young chicken, the average of 4 values for raw breast and thigh was used. The fluoride content of hand-deboned turkey is the average of 4 values in Table 9, adjusted for cooking changes.

5/ Values for lead in MDP and hand-deboned poultry are from Table 12. Lead values for hand-deboned young chicken and turkey have been assumed to be the same as for mature chicken. The value for lead in MDP from young chicken is for broiler backs made with kidneys with maximum lead content.

6/ Values for cholesterol are from Table 28. Values for MDP from young chicken and turkey were calculated from USDA values of 1.20 and 0.97 mg per g respectively for raw chicken parts and raw turkey parts.

Appendix Table VII-2. Calculations of Daily Per Capita Consumption of Cadmium, Calcium, Fluoride, Lead, and Cholesterol from Poultry, With and Without Mechanically Deboned Poultry

A. Per capita poultry intake is 52.9 lb. per year (1976 data - Appendix V-1) = 66 grams raw poultry per day = 46 grams cooked poultry per day (assumes 70 percent yield with cooking).

B. Poultry is 85 percent ready-to-cook, 15 percent further processed (1976 data). Therefore, daily consumption is 39.1 g ready-to-cook, 6.9 g further processed.

C. Data for contents of minerals and cholesterol in ready-to-cook and further processed poultry with and without MDP are taken from Appendix Table VII-1.

D. Cadmium consumption:

No MDP -- 0 mcg.
All "further processed" is MDP -- 6.9x0.036 = 0.25 mcg.

E. Calcium consumption:

No MDP -- 39.1 x 0.160 + 6.9 x 0.191 = 7.6 mg
All "further processed" is MDP -- 39.1 x 0.160 + 6.9 x 1.653 = 17.7 mg.

F. Fluoride consumption:

No MDP -- 39.1 x 0.89 + 6.9 x 0.84 = 40.6 mcg.
All "further processed" is MDP -- 39.1 x 0.89 + 6.9 x 5.86 = 75.2 mcg.

G. Lead consumption:

No MDP -- 46 x .02 = 0.92 mcg.
All "further processed" is MDP -- 39.1 x 0.02 + 6.9 x 0.017 = 0.90 mcg.

H. Cholesterol consumption:

No MDP -- 39.1 x 0.86 + 6.9 x 0.79 = 39.1 mg.
All "further processed" is MDP -- 39.1 x 0.86 + 6.9 x 1.51 = 44.0 mg.

Appendix Table VII-3
Calculations of Daily Per Capita Consumption of Iron and Zinc
From Poultry, With and Without Mechanically Deboned Poultry

I. Weighted Contents of Mineral in Poultry:

Type of poultry	Proportion of 1976 production	Iron Content		Zinc Content	
	%	mcg/g	total mcg	mcg/g	total mcg
Ready-to-cook, hand-deboned:					
Young chicken	79	1/ 16	12.64	1/ 18	14.22
Mature chicken	4	1/ 67	2.68	1/ 13.8	.55
Turkey	17	1/ 18	3.06	1/ 32	5.44
Weighted value	100	-	18.38	-	20.21
Further processed, hand-deboned:					
Young chicken	38	1/ 16	6.08	1/ 18	6.84
Mature chicken	26	1/ 67	17.42	1/ 13.8	3.59
Turkey	36	1/ 18	6.48	32	11.52
Weighted value	100	-	29.98	-	21.95
Further processed, MDP:					
Young chicken	38	2/ 39	14.82	3/ 25.9	9.84
Mature chicken	26	2/ 44	11.44	3/ 18.6	4.84
Turkey	36	2/ 43	15.48	3/ 44.7	16.09
Weighted value	100	-	41.74	-	30.77

1/ Amount in cooked poultry.
2/ Amount in cooked poultry. Values for young chicken and turkey were calculated from values of 27 and 30 mcg per g respectively for raw products, assuming shrinkage with cooking of 30 percent and no loss of iron.
3/ Amount in cooked poultry. Values for young chicken and turkey were calculated from values of 18.1 and 31.3 mcg per g respectively for raw products, assuming shrinkage with cooking of 30 percent and no loss of zinc.

II. Calculations of iron and zinc consumption:

A. Per capita poultry intake is 52.9 lb. per year (1976 data) = 66 grams raw poultry per day = 46 grams cooked poultry per day (assumes 70 percent yield with cooking).

B. Poultry is 85 percent ready-to-cook, 15 percent further processed (1976 data). Therefore, daily consumption is 39.1 g ready-to-cook, 6.9 g further processed.

C. Iron consumption:

No MDP -- 39.1 x 18.4 + 6.9 x 30.0 = 926 mcg (0.9 mg)
All "further processed" is MDP -- 39.1 x 18.4 + 6.9 x 41.7 = 1007 mcg (1.01 mg)

D. Zinc Consumption:

No MDP -- 39.1 x 20.2 + 6.9 x 22.0 = 942 mcg (0.9 mg)
All "further processed" is MDP -- 39.1 x 20.2 + 6.9 x 30.8 = 1002 mcg (1.0 mg)

Appendix VIII

Calculation of Infant Intake Levels of Mechanically Deboned Poultry

Appendix VIII.

Calculation of Data on Consumption of Mechanically Deboned Poultry by Infants

The infant food consumption survey data were collected from a national sampling of names chosen at random from birth lists. The sample was as representative as possible of geographic sections, educational level of parents and family income. The sample tended to be biased toward upper income categories, and some resampling was necessary to obtain lower income families. The study was conducted three times, in 1972, 376 infants were evaluated; in 1974, 136 infants; and in 1977, 151 infants. For each survey, the same methodology was used. Questionnaires and forms for recording all food intakes for four consecutive days were mailed to the respondents after they had been contacted by telephone and had agreed to participate. The forms requested information on the quantity of food consumed and the brand name, as well as the time of feeding. Summarized results of these surveys have been presented (Ap-1, Ap-2, Ap-3).

For use in the MDP report, the raw data on poultry products consumed by each infant were released to the USDA through the National Food Processors Association. For each infant, the weight in grams of poultry ingredients consumed was calculated, using estimated maximum percentages of poultry in baby foods. "Adult" soups and "adult" chicken stews were also reported as being eaten by the infants surveyed, and the amount of poultry consumed from these products was included in the daily intake. Consumption

of chicken or turkey skeletal meat (for example, chicken drumstick) was not included in the estimates of poultry ingredients consumed, since it would not be replaced by MDP.

Calculated values for intakes of poultry and of chicken were summarized by year. Mean, median (50th percentile) and 90th percentile values were calculated for each year. Because the intake data did not show a normal distribution around the mean, 50th percentile consumption values were used in making health and safety evaluations for this study. Intakes of potentially hazardous substances were calculated from these 50th and 90th percentile consumption data, as described in Tables 5, 11, 15, and 30. Comparisons of mean and median values for consumption of poultry and of chicken are given in Appendix Table VIII-1.

Appendix Table VIII-1. Comparison of Mean and Median Intakes of Chicken and Poultry by Infants

Year	Chicken Ingredients			Total Poultry Ingredients		
	Subjects	Mean	Median	Subjects	Mean	Median
	no.	g/day	g/day	no.	g/day	g/day
1972	208	4.9	3.2	234	6.0	4.5
1974	79	4.8	3.0	95	5.6	3.5
1977	89	4.2	2.2	116	4.1	2.2

Appendix References

Ap-1 Purvis, G. A. (1973). What nutrients do our infants really get? Nutrition Today 8(5): 28-34.

Ap-2 U.S. Senate, Select Committee on Nutrition and Human Needs (1974). National Nutrition Policy Study Series 74/NNP-6A. Government Printing Office, Washington, D.C., June 21.

Ap-3 Purvis, G. A., Wallace, R. D., Skeberdis, J. H. and Stewart, R. A. (1978). The role of the diet in the nutrition of U.S. infants. Presented at the XI International Congress of Nutrition, Rio de Janeiro, Brazil. August.

Appendix IX

Estimated Consumption of Cadmium
from Mechanically Deboned Fowl
With Kidneys

Appendix Table IX-1. Estimated Consumption of Cadmium from Mechanically Deboned Fowl with Kidneys 1/

Age Group	Body Weight (BW)	MDP 2/ Intake (Avg)	Cd Intake (Avg Cd content)	Cd Intake (Max Cd content)	MDP 3/ Intake (90th Percentile)	Cd Intake (Avg Cd content)	Cd Intake (Max Cd content)
years	kg	mg/kg BW	mcg/kg BW	mcg/Kg BW	mcg/kg BW	mcg/kg BW	mcg/kg BW
0-2	12.2	259.1	.036	.090	767.5	.105	.268
3-5	17.9	312.3	.043	.109	675.0	.092	.236
6-12	32.7	312.7	.043	.109	725.5	.099	.253
13-17	56.1	236.1	.032	.082	537.5	.074	.188
18-24	65.3	182.8	.025	.064	482.0	.066	.168
25-44	70.2	162.8	.022	.057	403.0	.055	.141
45+	71.3	129.8	.018	.045	326.0	.045	.114

1/ Source of data for body weights and intakes of MP(S)P: reference C-12. Values for cadmium in cooked MDP were calculated from values given in Appendix Table VI-1 for MDP made from raw fowl with kidneys, and assume a 70 percent yield with cooking. These values are (mcg per g): average cadmium, 0.137; 90th percentile cadmium, 0.349.

2/ Assumes average intakes of MDP equal to those of MP(S)P, and that MDP is present at the 100% usage level. Assumes that MDP is present in baby foods.

3/ Assumes 90th percentile intakes of MDP equal to those of MP(S)P, and that MDP is present at the 100% usage level. Assumes that MDP is present in baby foods.

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